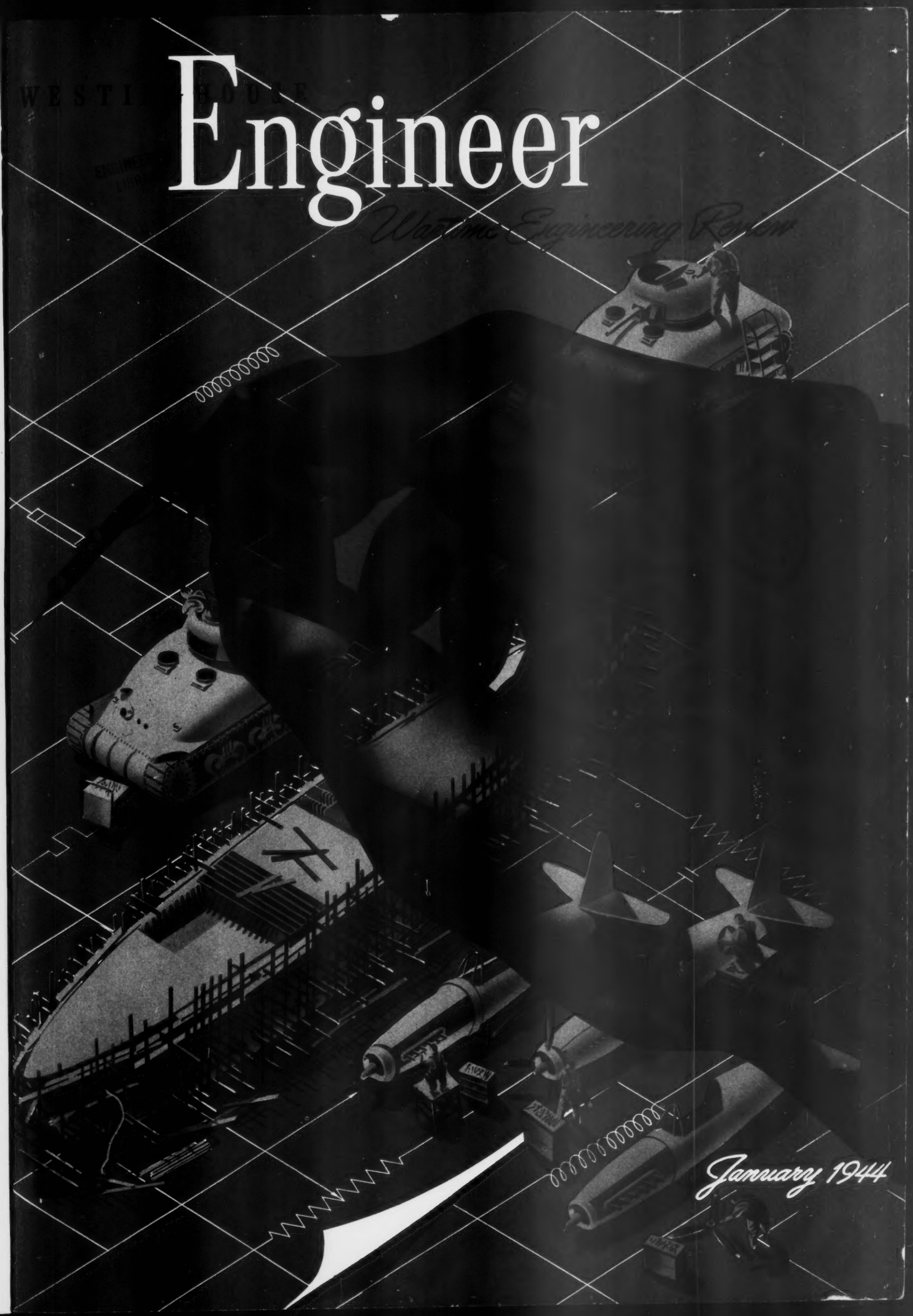

WESTINGHOUSE
Engineer
Wartime Engineering Review
January 1944

The War and Engineering Take a New Turn

How different the aspects of this war now as compared to those existing when the review went to press in the late fall of 1942! The war itself was much grimmer then. The North African campaign, just begun, was still touch and go; the Italian armies were an important factor on the side of the enemy; the U-boats roamed at will in the Atlantic; the Japs had only recently been halted in their southward drive and they were intrenched in the Aleutians; Australians were fearful.

In the year elapsed, the Allies have scored many victories. Although only a start has been made on the costly, bloody job ahead, the eventual outcome of the war is no longer in doubt. Italy has been taken out of the enemy's ranks; Berlin and Tokyo are clearly doomed.

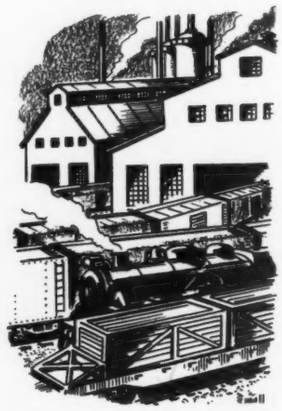
This favorable turn in the course of the war has been paralleled by a corresponding change in the engineering on which all the fighting rests. In 1942 the tools for fighting the war were still being developed, still emerging in basic form from the laboratories. The engineering review prepared a year ago told of new gun controls, generators for aircraft, pack radios, wind-tunnel drives, new factories, critical materials and shortages problems.

1943 has been different. Only a few new war tools were announced; some secret in 1942 still are secret. In engineering, the year just gone was, for the most part, one of refinement, of obtaining faster, smoother production of accepted and war-proved weapons. The war factories have long been built and are in production. Fear that the war effort might be crippled by lack of some indispensable material has been allayed by the skill and ingenuity of research men and design engineers.

The winning of Guadalcanal, the rupture of the Nazi grip on Moscow, the freeing of North Africa are spectacular because they signify the turn. They are, however, no more important for the final victory than the taking of Messina, the winning of the Volturno River, or the capture of Lae. Likewise the victories on the engineering front in 1943 are as outstanding as those of 1942. Life of carbon brushes for high-altitude planes has been multiplied a hundredfold; a means has been found for turning out monthly 26 instead of 14 sets of gears for Victory ships; a new manufacturing trick saves a fifth of a mile of arc welding on each gear case for cargo ships; gyroscopic controls have been greatly extended to gun firing controls—these are but some of the many conspicuous contributions made by the engineer during the last year.

The material for this twentieth edition of the annual Westinghouse engineering review is selected on a sampling basis. There is no thought of completeness. If space did not limit these stories, censorship would. No attempt has been made to include the developments in all categories of electrical equipment. Stories that bear directly on the war predominate, but behind them can be seen unmistakable evidences of postwar benefits.

Once the groundwork of principles has been laid appropriate devices and machines can soon follow. And in this respect this wartime engineering has been fruitful. In the words of Mr. Walter Evans, Vice President, Westinghouse Radio Division, "We have in three years accomplished in establishing new principles in electronics what normally would have required 20 years." The engineer is ready to turn from exercising his fullest ingenuity for new and more destructive machines to the building of a postwar world rich in machines evolved for the betterment of his fellow man.



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Engineering

VOLUME FOUR JANUARY, 1944 NUMBER ONE

WESTINGHOUSE Engineer

MARINE 2

Destroyer escorts . . . marine drives . . . binoculars . . . gear cases . . . instruments . . . test mast . . . firing motor . . . signaling searchlight.

AIRCRAFT 7

Standard d-c motors . . . high-altitude brushes . . . high-altitude test chamber . . . airport lights . . . packaged airports.

USES OF POWER 12

Corrosion-resisting zinc surfaces . . . electrostatic air cleaners . . . no-blink fluorescent switch . . . camera test of tank-gun stabilizer . . . super-accurate electric gauge . . . high-speed a-c motor . . . stabilization of a-c arc welding . . . laundry studies . . . gyroscope motors.

GENERATION AND DISTRIBUTION OF POWER 20

Protection of long transmission lines . . . new turbine impulse blade . . . smaller high-voltage potential transformer . . . power train . . . mobile railway substation . . . protection of air-cooled transformer . . . copper-oxide rectifiers . . . dynamotors . . . flexitest relay.

ELECTRONICS 26

Mass spectrometer . . . dew-point indicator . . . high-frequency heating . . . carrier current . . . x-ray . . . navy radio . . cores for high-frequency transformers . . . transformers for aircraft.

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Many of these scrappy destroyer escorts are being driven by turbines operating at higher speeds than are customarily found even in naval vessels. The high-pressure element turns at 9000 rpm, the low-pressure at 8000. The drive requires less than one half the weight and space of a conventional slow-speed drive. (U. S. Navy photo)

DEVELOPMENTS FOR MARINE USE

More ships, better ships, faster ships have been the objectives of engineering in 1943. Conspicuous among the efforts of engineers in this direction have been ways of making more gears and turbines from a given amount of machines and man-hours, both now at about their upper limit. Higher gear-tooth loadings, faster speed contribute to less weight for some types of ship drives. A new type of control permits cargo winches to be operated from centralized points on the decks, so this vital work can continue even though mishap befalls the deckhouse. Lighter weight welding equipment speeds repair to damaged ships at sea. A new, greatly simplified propeller-type blower driven by a single-stage turbine gives assured draft for the furnaces even with an electrical power shortage. New mechanical designs provide greater resistance to damage from shock. The stories here, chosen as representative, range from improved drives to greater comfort for the crews.

When Time Calls the Tune

In an engineer-made world, satisfactory performance and economy of dollars are usually the most important ruling factors. However, in a world at war, time and performance dominate. Many things are done to save time that would not ordinarily be attempted because of the greater cost. For example, although steam engines for ship drives were outmoded years ago, the first of the exceedingly valuable destroyer escort vessels were equipped with reciprocating steam engines. They could be obtained months earlier than the more efficient turbine and gears, or electric generators and motors. Normally an undesirable move, with the battle of the supply lines hanging in the balance last summer it unquestionably was good engineering.

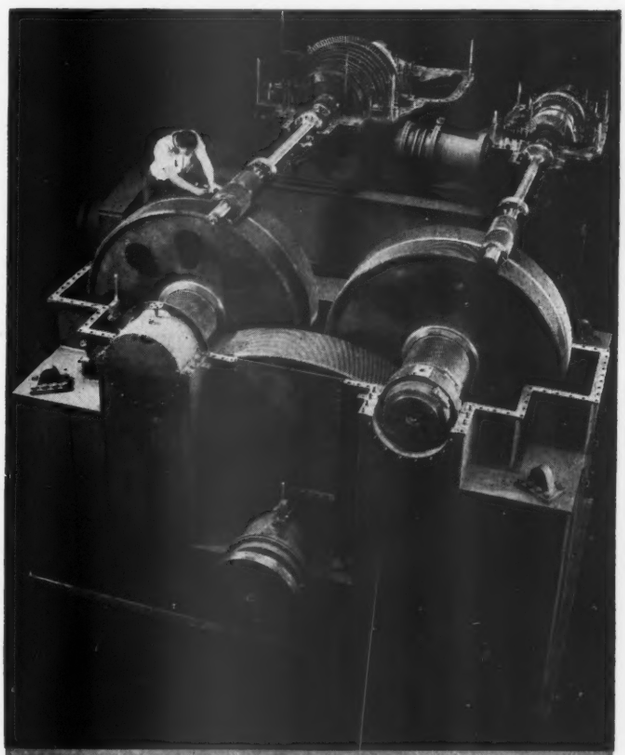
Much of this sort of thing is being done in this war, and it is surprising that so much of it represents not a loss but a gain, as well as a reduction of critical man-hours required, thus helping to win the all-important battle of time. One change alone is making it possible to turn out 26 sets of main gears per month for Victory ships from the available hobbing machines instead of 14, or nearly twice as many. This came about largely as a result of a rearrangement of the gears in the "nest" to eliminate the space between the two helices of the big, nine-foot diameter main gear, popularly known as the bull gear. By doing so the teeth on the two helices could be rough and finish cut by the two heads of the gear-hobbing machines simultaneously instead of as separate series operations as before when the gears were separated by about 30 inches. Thus a bull gear can be cut in about 6 days instead of 17. Additional factors in the improvement are an increase in speed and an increase in tooth loading.

This change also resulted in minor improvements such as the simplification of the bearing supports in the gear case. The method of nesting the rotating parts in the gears for the Victory ships is not new. As a matter of fact, it was used in Westinghouse gears employed in propelling the famous Coast Guard cutters of the Spencer class. To avoid the use of a third bearing on the first reduction pinions, the shaft between the helices has been increased in diameter sufficiently to keep the bending deflections within desirable limits.

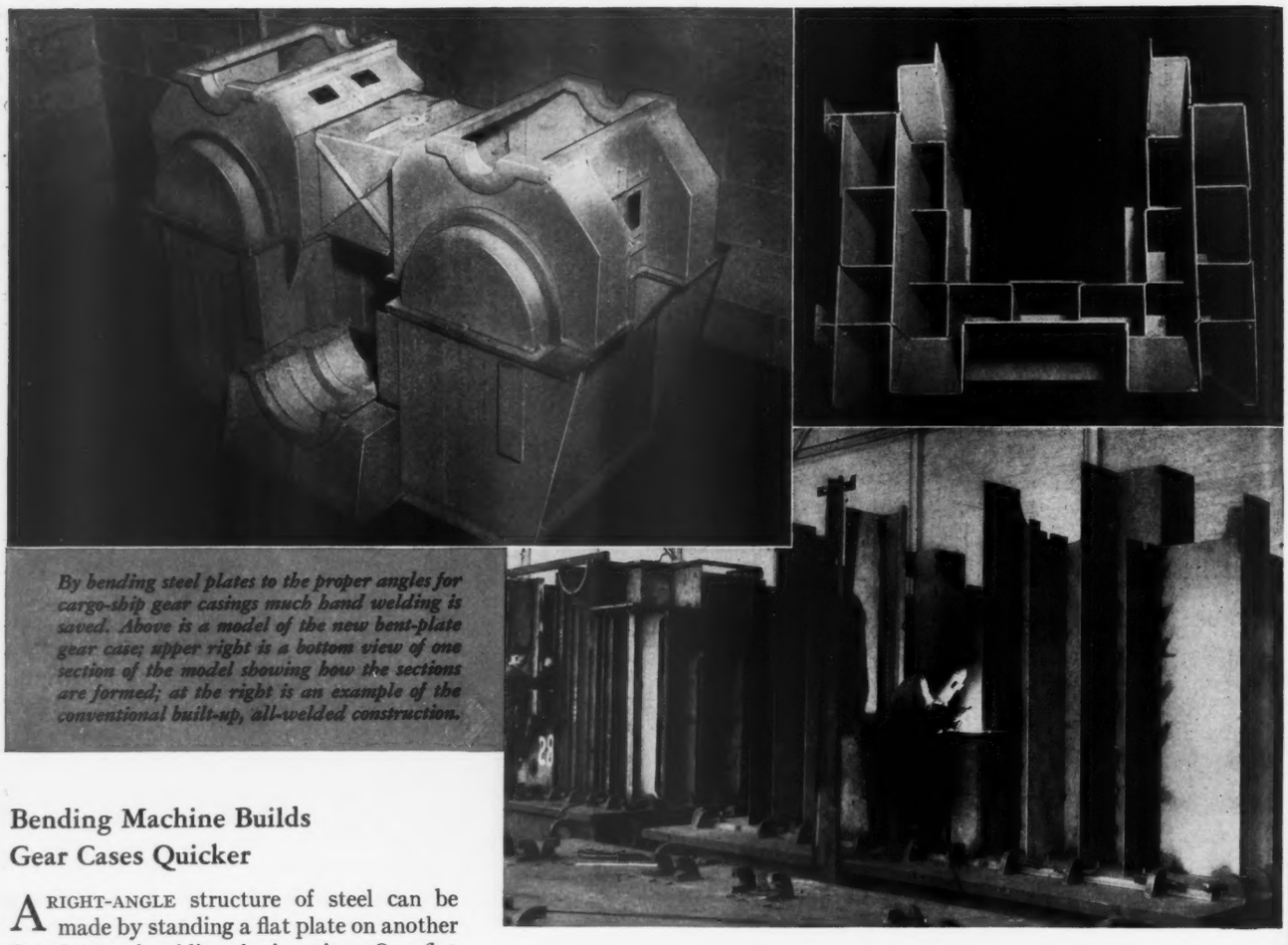
Another advantage of this nested gear arrangement for ship propulsion is that the second torsional critical speed—the potentially serious speed—is always well removed from the full speed rpm of the ship. In the Victory ship it occurs at nearly double the 100-rpm operating speed.

In the construction of the geared-turbine drives for these new cargo vessels much time has been saved by using fabricated steel structures in place of castings wherever possible. Foundries have been overloaded so that quick delivery of castings is impossible. Even when the castings are made a delay often occurs because of the shortage of labor on the chipping and cleaning floor of the foundry. As a result of this pressure to circumvent foundry delays, even the low-pressure turbine on these ships has a welded steel-plate cylinder. Almost a third of the man-hours originally thought necessary for the low-pressure turbine has been saved by the switch to a welded-steel construction. The reason for this is found principally in the fact that there is less excess material to machine away because in the fabricated cylinder the machined surfaces can be built much closer to the finished dimensions than is possible with the cast cylinder. This has been of particular advantage in reducing the load for the large planers.

It also made possible some incidental improvements in the construstion of the supports for the suspended condenser, the weight of which is taken by the low-pressure turbine.



Here is the drive for a modern cargo ship. The high-pressure turbine, upper right, exhausts steam to the low-pressure unit at the left. Each turbine is directly connected to the pinions of the first-reduction gear, which in turn drive a single big second-reduction gear just visible inside the case and from which projects the propeller shaft (lower center).



By bending steel plates to the proper angles for cargo-ship gear casings much hand welding is saved. Above is a model of the new bent-plate gear case; upper right is a bottom view of one section of the model showing how the sections are formed; at the right is an example of the conventional built-up, all-welded construction.

Bending Machine Builds Gear Cases Quicker

A RIGHT-ANGLE structure of steel can be made by standing a flat plate on another flat plate and welding the junction. Or a flat plate can be bent into a right angle. This simple fact, put into practice in the production of the gear cases for 226 new Victory ships, is resulting in the elimination of 50 miles of welding as compared to the standard 8500-hp gear case. Compared on the same basis, to the saving of 180 000 man-hours of skilled welders' time it meant the saving of 360 000 pounds of welding rod—both critical "materials."

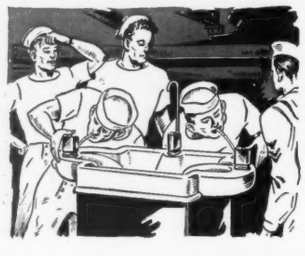
The housing for a big double-reduction gear of a turbine-driven cargo vessel is a complicated structure. It must enclose and support the rotating elements. The gear case must also be stiff enough to maintain accurate alignment of the pinion and gear-wheel bearings for the five rotating elements, the reactions on which, at full load, are extremely heavy. It has heretofore been made by building up a structure of flat iron plates and seam welding them. The new one for the Victory ships was redesigned to make use to the greatest degree possible of bent plate.

In addition to its economies in man-hours and material, somewhat greater stiffness is achieved. Also, unlike previous gear cases that had to be built from the ground up as a unit—one piece at a time—the new gear can be built as seven separate subassemblies—four for the base, three for the cover—and finally put together in one unit. The subassembly idea has many manufacturing advantages that result in savings in production time. The parts are much easier to handle and more quickly assembled. Perhaps most important of all is that the parts are lighter and hence can be turned easily to any position. Thus nearly all welding can be done in a down-hand position, of advantage because overhead or vertical welding is slower and requires more skilled welders.

More Efficient Water Coolers for Ships

WHILE most engineers have been intensively scheming to make the war as unpleasant as possible for the enemy, others are working equally hard to minimize war's discomforts for our own fighting men. Cool drinking water aboard ship, for example, is a great boon, rarely available in previous wars. Mechanical water coolers aboard troop transports, naval vessels, and other ships are doing a vital job.

Although the new water coolers look like those commonly seen in offices and corridors of public buildings, the water coolers for marine, and especially for naval service, must meet more severe requirements than normally. The most common size of commercial water cooler is rated at 10 gallons of water per hour chilled to 50 degrees. But this assumes the intake water is not warmer than 80 degrees F. However, water in a ship's reservoirs is often closer to 100 degrees. This means nearly double the load on the cooling mechanism, and ordinarily would necessitate increasing the size or decreasing its capacity—which engineers were willing to do.



The answer was found by devising a more efficient "pre-cooler." On the average, a person drinks only about 40 per cent of the chilled water turned on, the remaining 60 per cent goes down the drain. The pre-cooler is a means of making this waste water

cool the incoming water. Previously this was done by wrapping the incoming pipe around the outside of the drain pipe. The new pre-cooler obtains about three times more "cold transfer" by using a large drain pipe (four inches in diameter, instead of ¾ inch) and brazing the incoming-water coil (⅜-inch tubing) inside it. This forces the waste water to cascade over the warm fresh-water tubing, greatly improving the heat transfer.

In addition to the increased cooling efficiency the marine-type water-cooler control must be able to withstand a 150-pound shock test and the complete cooler must operate satisfactorily when tilted at intervals 40 degrees from the vertical.

Modernized Long-Scale Instruments

ELECTRICAL equipments, like people, ideas, and philosophies, are frequently ahead of their time. In 1898 and again in 1912 long-scale electrical instruments were available in which the scale extended over nearly the full circle of the dial. However, because of the lack of exact science in the designing and processing of springs, permanent magnets, and other vital parts in those days, these instruments were not considered successful and were abandoned in favor of the 100-degree scale that has been standard for two decades.

When the Navy embarked on its gigantic ship-building program at the outset of the war, its engineers believed it necessary to retain scale lengths at least as long as in six-inch instruments but at the same time wanted a space-saving design. They requested the industry to return to the long-scale (250 degrees) instruments for all our fighting ships. This called for the most ambitious, most gruelling instrument-design program ever attempted.

A large corps of engineers worked without let-up seven days a week for months—but, in 16 months the first production units were assembled, the completion of a program that would normally require six years. In one sense the engineers had a field day. It was as though architects were given an opportunity to build a complete modern city on new ground, using nothing but latest materials and designs, unhampered by existing constructions, and with all services completely integrated. For the first time in instrument history a line of instruments—a-c and d-c ammeters, voltmeters, a-c wattmeters, power-factor meters, frequency meters, and synchroscopes—was designed from the ground up, using all the accumulated experience with instrument design and use of newest magnet steels, spring materials, kinds of tools, each instrument correlated with every other one. It allowed an opportunity for standardization and unification of parts, frames, sizes, etc., not normally possible.

The new long-scale instruments are further outstanding in that, although the long-scale construction is inherently more complex than that of the 100-degree instrument, the new Westinghouse instruments are so simple in construction that they can be disassembled and repaired with ordinary tools by regular instrument repairmen without additional training. The instruments are unbelievably sturdy, in order to meet the high-shock conditions encountered in naval service. They are able to pass the 2000-foot-pound shock test in which the steel test panel on which the instruments are solidly mounted is smacked by a 500-pound weight dropped four feet, first on the top, then from the rear, and then from the side. This test momentarily increases the weight of each part by 3000 times, which is equivalent to supporting the weight of two light automobiles from each instrument. After this test the instruments must continue to operate with acceptable accuracy.

Although the entire output of these instruments will be required by the Navy for some time, it is expected that these instruments will have considerable land application when production facilities are available for that purpose.

A Land-Going Ship's Mast

A MAST, several hundred miles from salt water, rolls more wildly than any crow's nest ever manned by a hardy sailor. This 50-foot steel tower swings from 45 degrees one side of vertical to a like tilt in the other (90 degrees total), making a round trip every six seconds. At the midpoint of its travel its top is moving 30 miles per hour, and the centrifugal forces are great enough that a man or an object would tend to fly upward instead of falling by gravity. The tangential forces at the ends of the swing are several times greater than the pull of gravity.

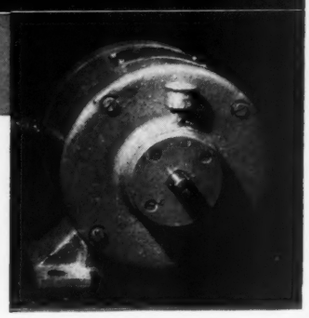
The purpose of this land-based mast is to test controls for electrical apparatus that are to be mounted on the super-

For testing apparatus to be mounted on masts this tower duplicates the effect of a heavy rolling sea.

structure of ships. These tests are required to determine if devices such as controls for searchlights, radio apparatus, or signaling devices will function uninterruptedly under such high centrifugal and tangential forces. No motion of a bed plate or table has been found to duplicate the actual effect of the mast of a ship rolling in a heavy sea. Engineers unable to simulate mast motion in the laboratory, first chartered an actual ship for experimentation, but lost patience when hoped-for storms failed to materialize, and finally built their own mast on land.

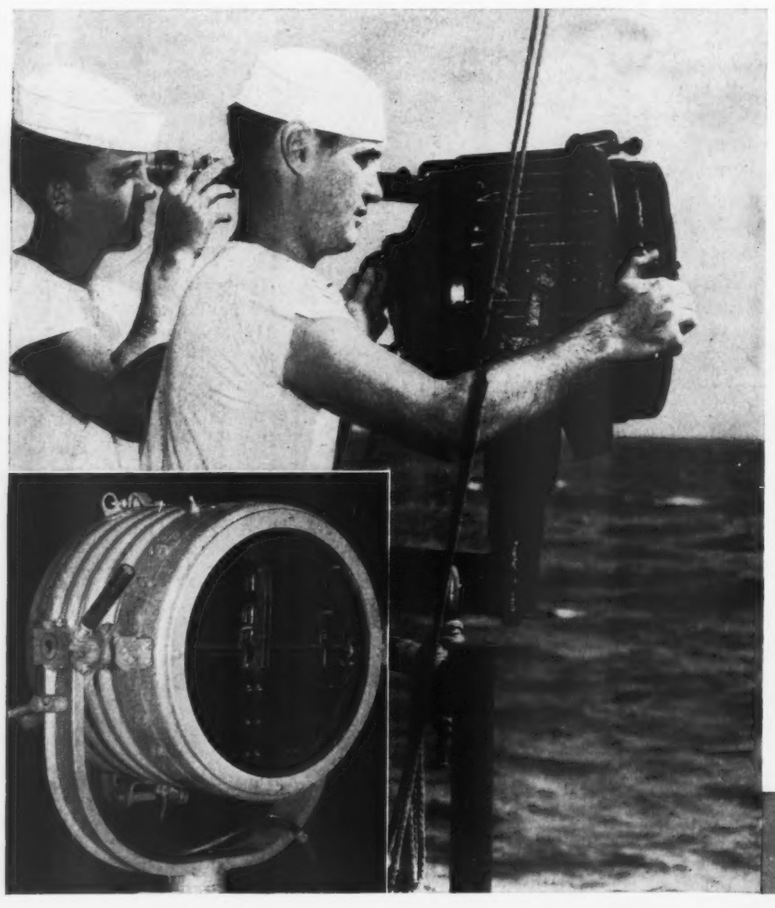
The mast is a strong steel tower, pivoted near the base and counterweighted. Rolling motion is imparted by a 35-hp variable-speed motor operating through a standard oil-well reduction-gear and crank. Both the speed of the mast and the angle through which it swings can be controlled over a wide range to provide nearly any desired cycle.

Receiving the full effect of the water is the motor at the right, for use aboard a fighting ship.



An Amphibious Motor

A SPECIAL electric motor is built to drive the cams of a multiple-barrel gun on ship, waves or no waves. It is a ⅓-hp induction motor built to Navy specifications and must operate after being squirted with a one-inch jet of water from a distance of ten feet. Waterproofness was achieved by a labyrinth-type seal with appropriate traps and drains. The seal uses no packing to cause friction or no rubbing metal parts to wear out. In addition to being waterproof the motor must be uninjured after receiving two 2000-foot-pound blows from each of the three directions. Engineers, to prove to themselves that these motors are well able to meet the severe Navy demands, subjected one motor to an additional shock test. After whacking the motor with a total of 150 of the 2000-foot-pound blows and finding no evidence of fatal injury, the test was stopped. Such a motor must have an especially sturdy frame, windings, and bearings.



The shutter of a Navy signaling searchlight must be quick-acting and have a long life of several million operations. (Action photo by U. S. Navy)

A Signaling Shutter That Can Take It

THE INDIAN-warrior method of transmitting silent messages was by smoke signals. The Navy uses an interrupted light beam. Whether the Indians had technical problems with the blanket used as a shutter is not known, but engineers have found it difficult to build one for signaling searchlights that is light in weight for fast operation and durable. To the Navy, long life means at least a couple of million operations. One solution has been to dodge the shutter problem by turning the light on and off instead, but lamp-control schemes have marked disadvantages. A new shutter construction meets the Navy's requirements of sturdiness and ease of operation at three cycles per second. It is a "venetian" blind affair using thin-gauge steel shutters operated by a lever mechanism to which special attention has been given to all bearing surfaces. This shutter has been operated over two million times, after which the test was discontinued, with the shutter seemingly able to continue indefinitely. One requirement that makes sturdy construction difficult is that the shutter must be light in weight for ease of operation.

ELECTRIFICATION OF AIRCRAFT

"A new design of airplane requires a period of from four to seven years." The engineering story behind that statement made recently by the president of a major airline would fill volumes. The work of the electrical engineer alone is staggering. In developing complete and ever larger and larger electrical systems for planes he is racing through most of the problems worked out by the electrical industry as it developed over many years. He must provide power plants, both a-c and d-c, and arrange for their parallel operation, control, and protection. High- and low-voltage distribution must be planned. Problems of transformation and rectification, motorized equipment, lighting, communication, and other apparatus must be solved. On top of all this, new factors control his design; apparatus must be the absolute minimum in weight, must be highly efficient, must have large electrical creepage distances, and must be highly efficient. Aircraft electrical apparatus must be reliable and must function in a wide range of temperature. Under the pressure of war needs the work is progressing at top speed. The few examples of electrical engineering applied to aircraft given here are selected not on the basis of relative importance but as being representative of the new problems.

A Family of D-C Aircraft Motors

AERONAUTICAL design engineers adopted hydraulic systems to operate the mechanical and auxiliary functions of planes primarily because of their availability and low weight. Planes were not too large, as measured by present-day standards, and extreme temperature and atmospheric conditions were not a problem such as the high-altitude planes of today present. Planes have grown in size, have increased in speed, and—with high-altitude operation—have encountered a multitude of functional and auxiliary operational problems difficult to overcome with hydraulic systems. With the design of light-weight, heavy-duty generators and light-weight, high-torque aircraft motors, electrically powered mechanical and auxiliary devices are rapidly replacing or supplementing the hydraulically operated equipment on planes of today.

The specific power requirements of each piece of functional plane apparatus have led to the design of a coordinated basic line of aircraft motors. These basic motors with their accessories, such as brakes, clutches, gear-reduction drives, limit switches, etc., result in motors tailor-made for the jobs they are called upon to perform. Typical devices operated by these motors are landing gear retractors, defroster fans, fuel pumps, booster pumps, flaps, trim tabs, blowers, cowl flaps, shutter doors, engine starters, propeller-feathering, anti-icing pumps, de-icing pumps, automatic pilot control, cabin superchargers, glider reels, turret control, ammunition loaders, bomb-bay doors, windshield wipers, and hoists.

These d-c aircraft motors vary in diameter from $1\frac{15}{16}$ inches to $6\frac{3}{8}$ inches, making it possible to obtain ratings ranging from 1/300 hp at 7500 rpm to 7 hp at 7500 rpm, continuously with self-ventilation. This range in ratings may be extended to 11 hp at 7500 rpm with forced-air cooling.

Governor control may be added to several of these motor sizes, when it is necessary to have extremely good speed regulation without complicated controls.

Some of the features available on this basic line of motors include; 1—brushes specially treated for long trouble-free life at high altitudes (see below), 2—bearings properly lubricated for extremely low and high temperatures, 3—mechanically strong construction to withstand shock and vibration of 15 times gravity, 4—large electrical creepage distances necessary for dependable, high-altitude operation in rarefied air, and 5—light weight, the ever-present requirement aloft.

Airplane Brush Life Increased Fiftyfold

CARBON brushes that wear down clear to the pigtails in an hour! Or even a hundred hours! To a power man, even the latter is unthinkable. However, airplane builders and operators are delighted with the new brushes that last one hundred hours in high-altitude flying, because previously the life of brushes was but an hour or two. Sometimes brushes would completely disintegrate in a single flight at altitudes of 30 000 feet and above. Research engineers, studying the phenomena of commutation in the substratosphere, found that the thin copper-oxide film normally present on the commutator surface at ground level is not maintained in the upper air. This oxide film acts as a lubricant for the brush face. Without it the carbons ride on raw copper, and, at the high speeds at which aircraft generators turn, are quickly ground to dust. Also, the absence of the film decreases the brush-contact re-

From research studies comes a treatment for carbon brushes that greatly increases their life in high-altitude service.

A Martin Mariner leaves a white-ribbon wake as it lands in the harbor on returning from anti-submarine patrol. (Official U. S. Navy photo).

sistance, which has an adverse effect on the electrical characteristics of the generator. Also, the high temperatures at which these commutators operate nullify conventional methods of bearing lubrication.

Armed with this information, research engineers developed a special treatment for brushes that creates on the commutator the necessary oxide film as rapidly as it is worn away. The result is a fiftyfold improvement in aircraft brush life, which is of great significance, not only now, but also in the high-altitude flying that is to come after the war.

Laying the Basis for 13-Mile-High Flying

ALTITUDE of 40 000 feet or more is a different world as far as electrical machines are concerned. That a motor, or generator, or control mechanism works perfectly at or near ground level is no assurance of satisfactory operation eight or ten miles up. Engineers are having to find out—and quickly—how these high-altitudes affect machines. To this end a large high-altitude chamber of unique abilities has been created primarily for the testing of motors, generators, and switches.

In this chamber conditions of 70 000 feet can be readily obtained. Temperatures can be lowered to minus 67 degrees F, the pressure to ¾ pound per square inch, or about 1/20 of sea-level pressure. Humidity also can be controlled.

These conditions are difficult to achieve because, to insure conditions identical to the stratosphere, all air forced into the chamber under controlled temperature, pressure, and humidity is fresh air. None of the air can be recirculated, otherwise brush dust and gases from the insulation would accumulate and falsify the test results. A mixture of crushed dry ice and varsol (akin to kerosene) is used as the refrigerant.

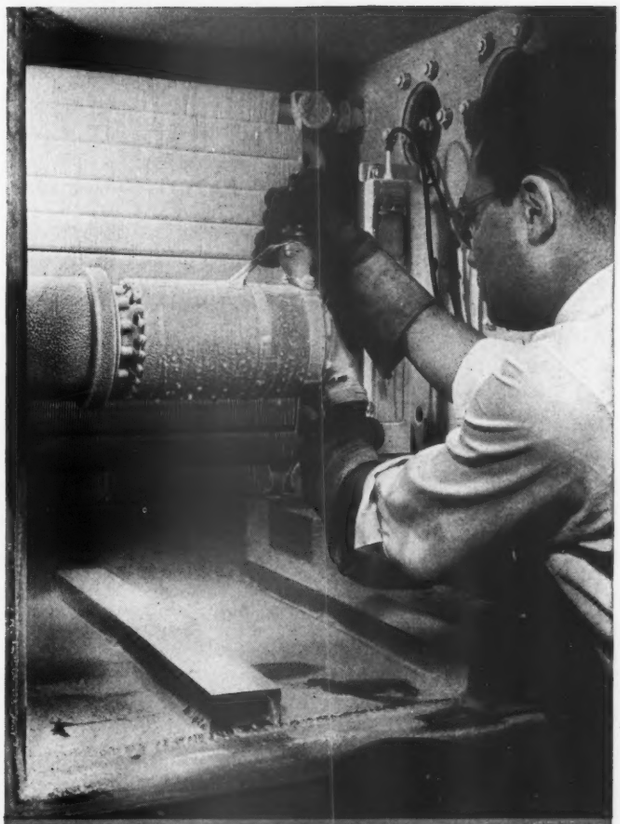
The incoming air can also be heated and saturated with water, thus simulating jungle conditions. In this way a complete flight cycle is duplicated both as to conditions and time. The electrical apparatus is subjected to a simulated take-off from a hot, steaming landing strip in a jungle, and climb at the normal rate to the cold, dry, rarefied air of the stratosphere. In fact, in the chamber the conditions are somewhat more severe than ever actually encountered.

Among the problems being probed in the chamber are brush wear, creepage distances required for different voltages, and ventilation needs of aircraft electrical apparatus. Having a laboratory of this sort where all conditions are under rigid control reduces the necessity for actual high-altitude flight testing, which is expensive, and time consuming.

New Landing Gear Demands Stronger Runway Marker Lights

BECAUSE airport contact or runway marker lights are placed along the edge of the runway, they must withstand being run over by the wheels of a fast-landing plane—and planes are becoming steadily heavier. Last year we spoke with pride in these pages of how engineers had created contact lights that would not crush under a pressure of 100 000 pounds, moving the limits up from 35 000 pounds.

This past year airplanes have appeared with landing gear like tank tracks instead of rubber-tired wheels. The combination of heavier planes and these "cats," instead of rubber tires results in a blow that can crush the 100 000-pound units. The steel cap of the new unit is supported on a steel spider—between the fingers of which the light rays stream almost parallel to the ground. It carries the crushing load downward at an angle to the steel ring resting against the concrete of the cell.



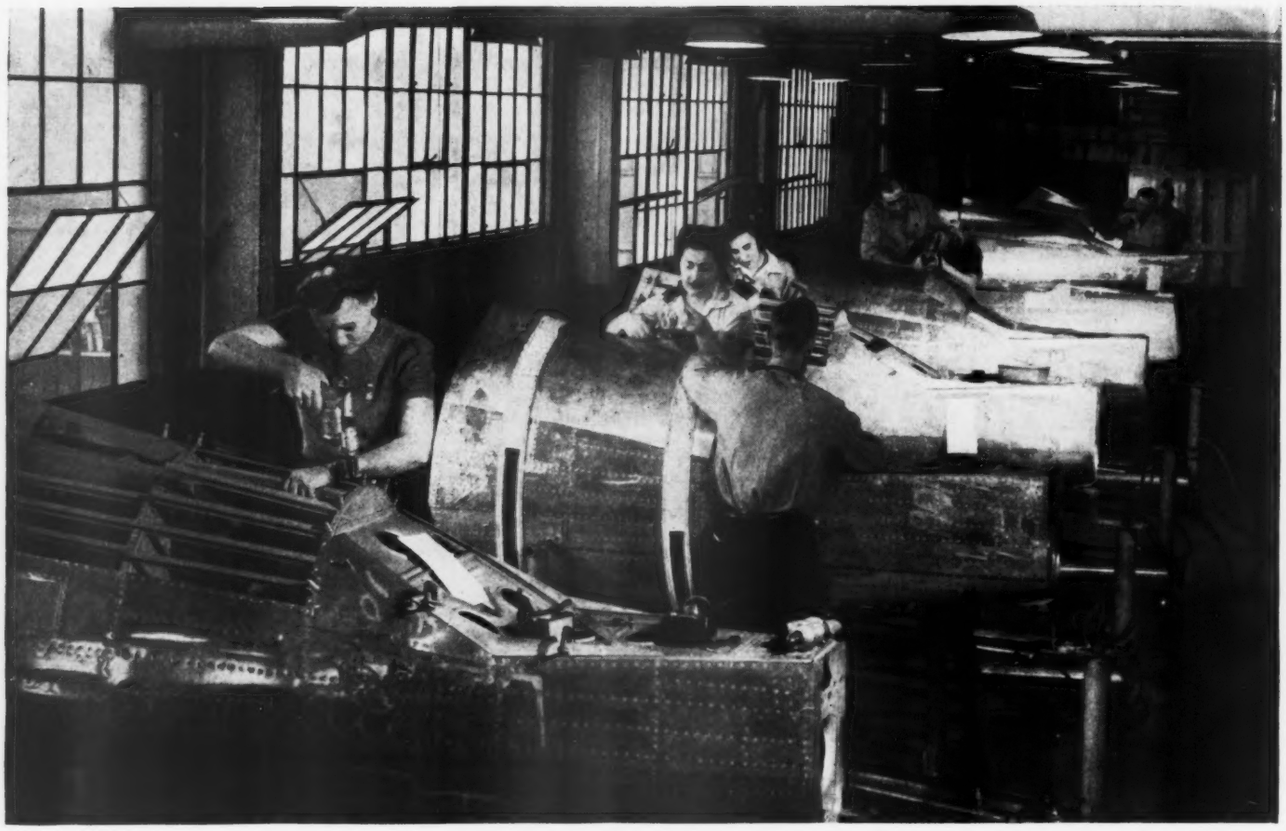
This well-frosted generator has, in effect, been to 70 000 feet altitude. In this chamber electrical equipment for planes can be put through any cycle of temperature and air pressure.

The new units, with mild-steel spiders, have repeatedly withstood loads of 150 000 pounds. If made of alloy steel, the units are good for better than 200 000 pounds. These almost-phenomenal increases in strength have been achieved without any increase in size. The dimensions are fixed by the fact that the units must fit into the concrete emplacements of which there are now many thousands lining the runways of scores of airports in this country and abroad.

New Motors Help Fighters Get on Top

IN AIR fighting the guy on top has tremendous advantage, hence the stiff competition among plane builders to provide fighting ships of higher and ever higher ceilings. In pushing upward these ceilings for planes they have been continuously successful and have left the limits of human ceilings far behind. The human ceiling can be lifted appreciably by oxygen devices, but it appears that ceilings to be obtained for future planes will make even these inadequate. Human endurance may again become the limiting feature of altitude fighting. To anticipate this end, engineers are at work to develop schemes of pressurizing the pilot's compartment.

Interesting is a motor still in the early stages of development for driving the supercharger. It is a 27-volt direct-current motor, weighing but 14 pounds, but capable of developing 1.2 hp at 8500 rpm or, which is more difficult, 1.9 hp at 15 500 rpm. The variable speed, in combination with a special control operative above 10 000 feet, will enable a safe pressure differential to be held in the cockpit automatically at all altitudes. This motor is particularly notable in that it achieves its



Where electric ranges once grew, parts for fighting planes now take shape. Mass-production ideas have been applied to improve the manufacture of engine mounts, stabilizers, tail cones, elevators, etc. Ordinarily the fewer parts, the less the cost. However, engineers found that by making the skins for engine mounts in two pieces instead of one the cost could be reduced by $24 with a saving of 50 pounds of stainless steel on each unit.

rating over the nearly two-to-one speed range by control of the field voltage instead of by armature-voltage control. This is made possible by a design which uses a compensating winding to nullify armature reaction, and thus obtain satisfactory commutation under the weak-field condition corresponding to the maximum speed. Field instead of armature control is desirable because the smaller currents involved greatly reduce the weight and power losses of the control apparatus.

The high maximum speed at which this motor will operate makes it necessary to provide steel music wire bands around the armature coil extensions to withstand high centrifugal forces, and to check the dynamic balance of the armature very closely. It has also been necessary to design a special commutator strong enough to withstand a test speed of 24 000 rpm and still have as small a diameter as possible to keep brush friction loss to a minimum.

A-C Systems for Planes Take Shape

ALTERNATING-CURRENT electrical systems for aircraft are now necessary as a result of the increasing size of planes, larger electrical loads, and higher altitude requirements. Until now, the principal limitation has been the lack of a suitable source of constant-speed power to drive the alternator. Now some devices have been tested and show considerable promise that a satisfactory constant-speed drive will be obtained. The first high-frequency, high-voltage a-c aircraft system supplied by generators driven by the main engines is already well on the way to realization. The component parts of the system are entirely new, including the alternator, motors, control, and distribution layout. Preliminary samples of much of the apparatus have already been produced—some are in the process of construction, and others are being designed.

The size of the alternator is only a fraction of that of a standard machine of comparable rating. An entirely new control system is being developed to provide reliability, minimum weight, fault clearance, and the ability to function with the alternators operating either isolated or paralleled. Intensive studies have been made of the requirements for two large airplanes. Automatic synchronizing equipment is being provided for the alternators. Extensive tests have been made to determine the self-clearing ability of faults at altitudes up to 40 000 feet. Special limiters have been built for sectionalizing faulted areas of the distribution system. New circuit breakers —small and light weight—are being created for this sytem. A family of basic 400-cycle a-c motors is also being developed.

Airport Marker Lights Are Standardized

ANYTHING that can be done to reduce needless complexity of the mechanical components of our civilization is all to the good. In this direction an important step has been taken in the standardization of airport marker lights. Twelve different lights have been used to mark airport boundaries, obstructions, wind cones, runway approaches, airway obstructions. There are about 20 manufacturers of these lights. Each builder had his own design and each lamp was different, which meant many parts for the Army and Navy to stock and assemble. To reduce this complexity the two services have adopted a single standard known as the AN-L10 marker light, which consists of several standardized parts from which any of the twelve different lamps can be made.

Packaged Airports

"We'd like to buy two dozen of your packaged airports, if you please."

"What size, gentlemen?"

"Twenty of B size and four of C."

"What climate?"

"Six B and four C, temperate. The others, tropical."

Such could be the essence of a conversation now. Developed for world-wide distribution by the Westinghouse Electric International Company in collaboration with the Construction Department of the Westinghouse Electric & Manufacturing Company are packaged airport equipments which comprise all facilities, down to the last doorknob, for an airport of any size with the exception of the large and always special main terminals. These packaged equipments include not only all the power and electrical apparatus, radio equipment for communication between airport and planes and between airports, lighting for field and buildings, and meteorological instruments, but also the prefabricated steel buildings for administration, office, living quarters, hangars, and such services as heating, plumbing, and sewage-disposal systems. Everything but the runways, in fact.

The four sizes of airports comprise every type but the large terminals. The smallest and simplest is the emergency landing field and has only the barest essentials to accommodate a plane forced down. The next is an airport that might be used by remote or isolated mines, ranches, or other concerns in connection with the operation of a property. Still larger is the feeder airport such as would be used by smaller communities, perhaps on branch lines, and finally the largest of all, the feeder airports of fair-sized towns on main airways.

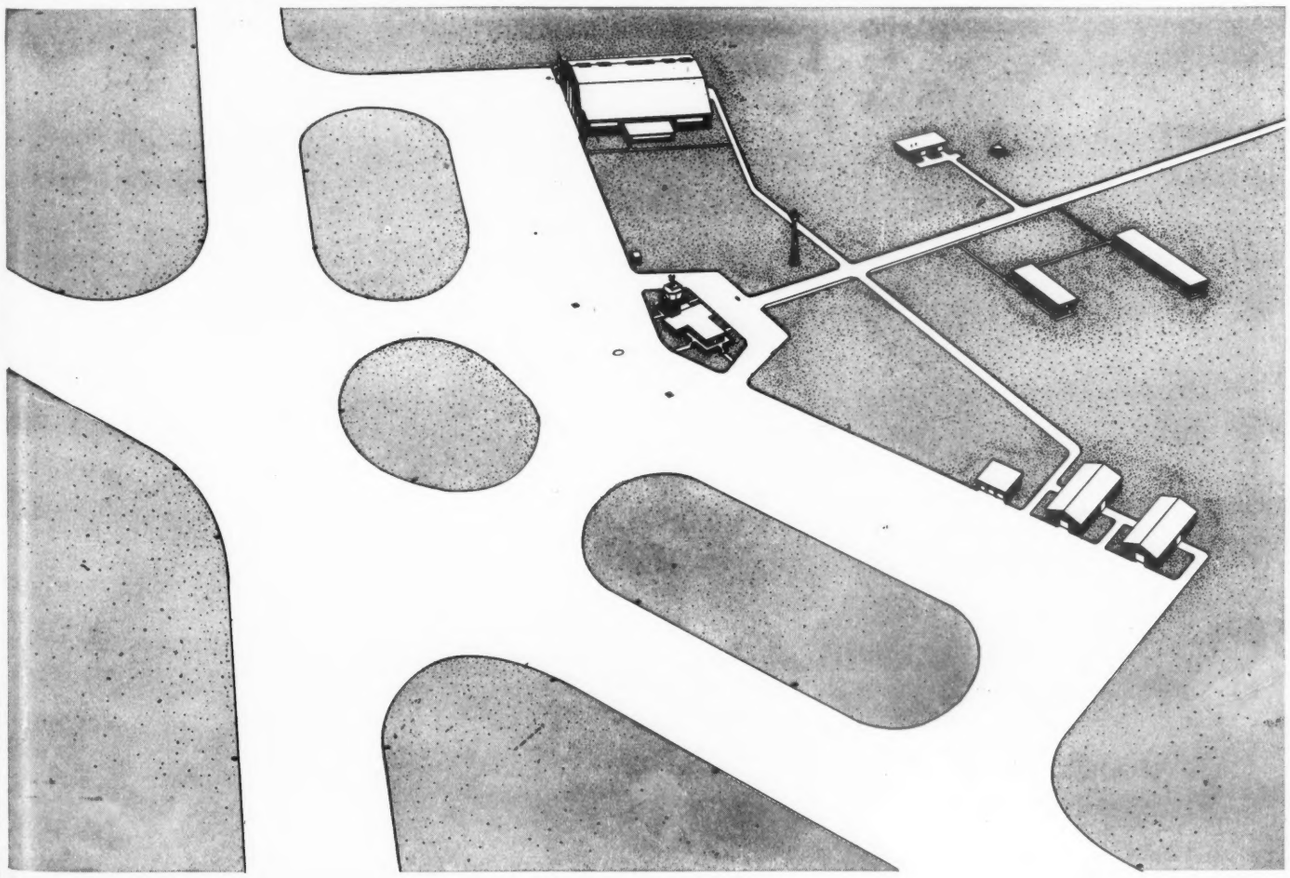
The prefabricated terminal building for tropical locations.

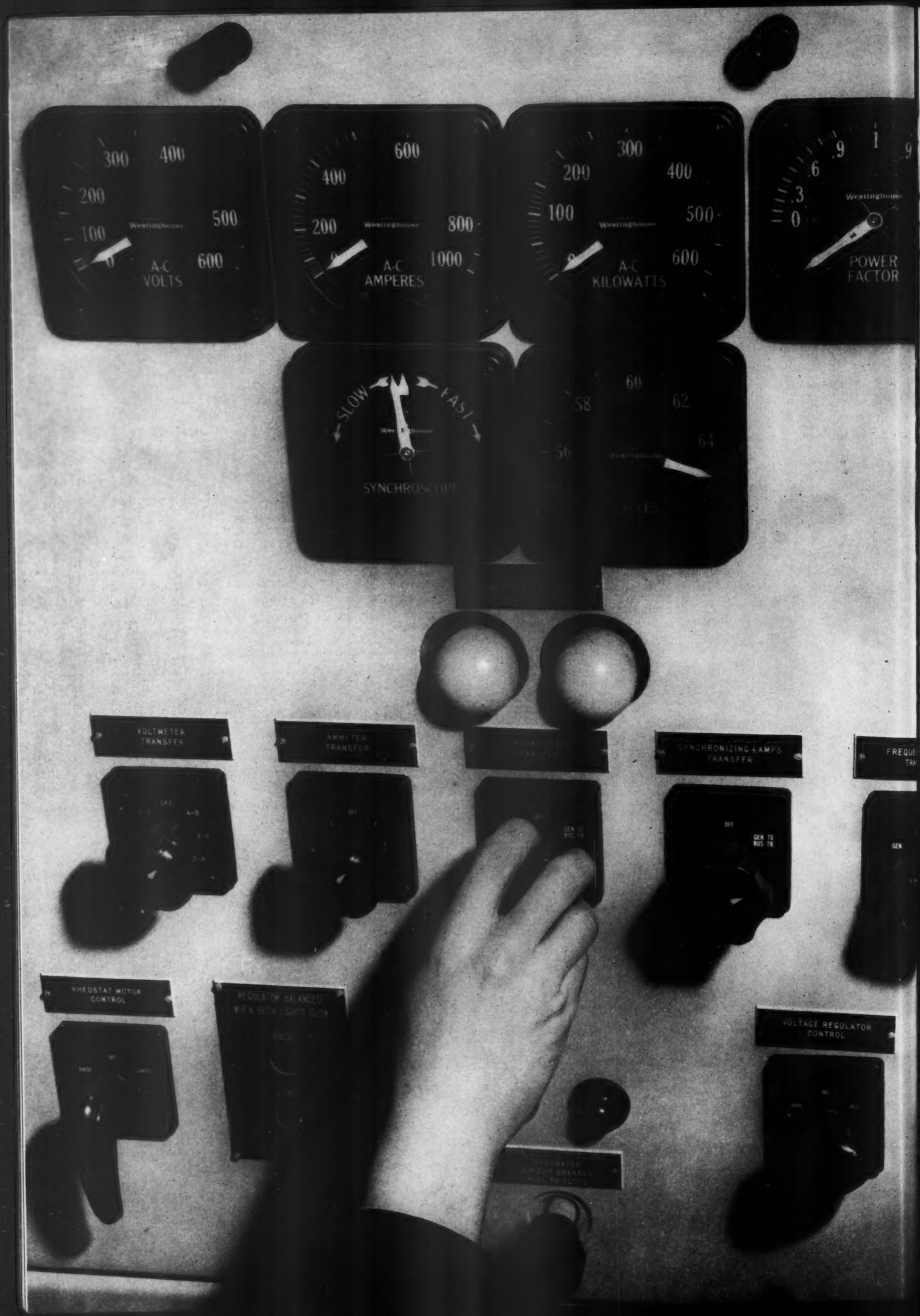
Because flying is a global business, climate becomes a dominant factor. The equipment for all four sizes of airports is engineered to three temperature classifications—polar, temperate, and tropical—each taking into account all the conditions of its class, including variation in temperature, moisture, wind, ice loading, insects, etc. Thus, for example, there is a total of 12 types of main terminal buildings.

Outstanding engineering feature of the packaged airport is the correlation of the basic elements and their reduction in number. This makes it possible not only to make up almost any desired airport by proper selection of the basic units but also permits the facilities of any given airport to grow as the need changes. For example, electricity for those airports that must provide their own power is supplied by one or more standard Diesel-driven generators.

The development in airplanes has generally been well ahead of airports and airport facilities. It is believed that these engineered packaged airport equipments will go a long way to assist in the enormous catching-up job for ground facilities that will be necessary in the postwar period.

Airports of the future may be arrangements of standard, prefabricated structures and standardized equipments purchased as complete units.




A-C VOLTS
A-C AMPERES
A-C KILOWATTS
POWER FACTOR
SLOW
FAST
SYNCHROSCOPE
VOLTMETER TRANSFER
AMMETER TRANSFER
SYNCHRONIZING LAMPS TRANSFER
RHEOSTAT MOTOR CONTROL
VOLTAGE REGULATOR CONTROL
OFF
GEN TO BUS TIE

POWER USES IMPROVED

Economic depressions, wars, material limitations—these things do not thwart engineering ingenuity; they only affect its directions. The steady procession of improvements in apparatus, new kinds of equipment, new ways of making use of power continues. The variety is endless. A new marble-size lamp achieves high efficiency but consumes one-tenth watt. Retainer rings of Mycarta for the balls of a bearing increase the allowable speed. Sterilamps augment food supply by decreasing mortality among chicks. A new method of bright electroplating aids corrosion resistance. These and the stories given here manifest the virility of modern engineering.

Titanium Helps Beat Corrosion

THIS IS the story of how an elusive, exceedingly minute "impurity" turned the tide in one battle of the longest, most costly wars in industrial history—the battle against rust. The ease with which our most important structural material—steel—oxidizes to rust has cost far more than all the billions to be spent in the present World War. Millions of dollars have been spent on paints, finishes, and treatments to delay the inevitable rusting. Conspicuous success has been achieved by treating metal surfaces with phosphoric acid solutions to increase paint adhesion and thereby improve corrosion resistance. Unfortunately zinc remained stubborn; it would not take the phosphate coating evenly in the ordinary phosphating process.

Early in this work a curious phenomenon was discovered. If the zinc surface is wiped by almost any means, such as with a hand, a brush, or a cloth, before it is treated, excellent and consistent phosphate coating results. Just why this is so is not altogether clear.

Knowing this, many methods of wiping the zinc surface before treatment were attempted. But in production, sure, uniform wiping is difficult even on plane surfaces and impossible on irregular objects.

In the manufacture of zinc-plated frames for outdoor-type watthour meters this problem of preparing the zinc surface to take the protective coating of paint became serious. A young Westinghouse chemist tackled the problem. His approach was to do the wiping chemically instead of mechanically. Countless dips were tried on the zinc surfaces with indifferent and inconsistent results.

One day he tried disodium phosphate. The results were excellent, and could be duplicated as long as that particular batch of phosphate lasted. But, with the next lot of disodium phosphate, the result was a failure. Something was different about the previous bottle of phosphate, but what it was was baffling. Ordinary chemical tests revealed no difference. Finally, in desperation, a more critical test was made. A faint trace of titanium—one part in a million—was found. Herein lay the answer. For some reason a mere whisper of titanium is the magic that makes the predip solution of disodium phosphate work as a chemical wipe on zinc for subsequent and final phosphating treatment.

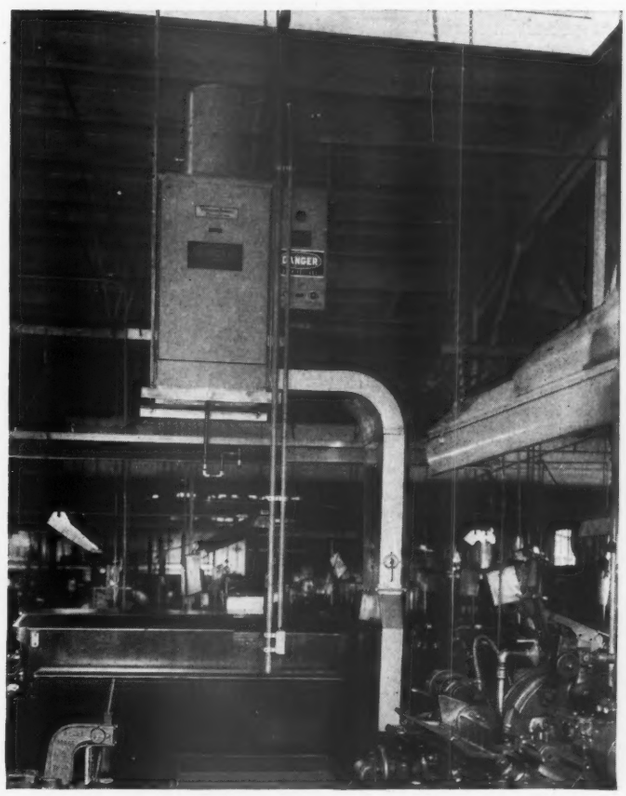
The process is now being applied extensively on a commercial scale for the protection of hundreds of zinc-coated parts of machines for both war and peace. Certain products plated with a layer of zinc but three ten thousandths inch thick and given the titanium predip and the normal phosphate coating are able to meet the 100-hour salt-spray test with ease. Without the titanium predip, corrosion of the zinc-plated parts appears in an hour or two.

...is modern switchboard with new long-scale instruments ...fies control of electric power.

Dust on the Run

DUST and dirt in the air levy a continuous toll on industry that is as serious as rust, but usually less conspicuous. An electrostatic dust precipitator, the Precipitron, has been one of the most valuable weapons in the war against the damage done to machines and to industrial plants. Its uses spread to an even wider circle during the year just passed.

Particularly successful has been the adaptation of the Precipitron to the catching of the oil mist at high-speed grinders caused by heating and thrashing the cooling oil as it pours over the fast-spinning tools. This oil mist has become serious enough in some plants as to cause fire hazard, to condense on and drip from walls and pipes, to lead to premature electrical insulation failures, and to make the working environment unpleasant. Precipitating the oil mist at its source not only eliminates these objections but also recovers the cooling oil for reuse. Also, some operators are now able to use a better, but more expensive cutting oil, with greater production. This use of the Precipitron, mentioned as experimental a year ago, has now been proved highly successful in dozens of plants.



The removal of oil mists, created by high-speed tools, using individual Precipitrons has been of great economic value to many war factories.

The war has brought new emphasis to food processing. In particular, it has made of dehydrated foods an industry of full stature. In this, electrostatic air cleaning is having a part. A firm preparing powdered milk found that by using an electrostatic air cleaner to keep dust out of the large volumes of warm air required for dehydration the plant could be built in the city close to distribution centers and to the labor supply, instead of in some cleaner but distant area.

Blast-furnace gases are used as fuel in gas engines or by gas furnaces. In either case dust coming over with the gas is injurious. It is ruinous to valves and cylinder walls in engines, and gums up the nozzles of furnaces. A small-scale trial of a Precipitron by one steel firm on its blast-furnace gas supply indicates that it can cope with this severe dust problem.

Automotive engine builders are experimenting with electrostatic air cleaners for installation on engines to lessen the internal wear caused by road dust. Based on highly successful results with a single pre-war trial of a Precipitron in a railroad car, plans are being formulated to build, when materials are available, an improved version of the unit for existing and new railroad coaches, diners, and Pullmans. Thus every car can become a smoking car.

A major improvement in electrostatic air-cleaner construction was effected last year by the development of a dust-collector cell with collector plates that stand on edge instead of lying horizontal. This greatly simplifies the cleaning procedure and permits the washing solution to drain off more rapidly.

Block That Blink

WHEN AN incandescent lamp burns out, it does so suddenly. A fluorescent lamp, on the other hand, does not quit all at once. Instead, it tries to start but is unable to sustain the arc. The result is a periodic flashing of the lamp that continues until the lamp is removed or the lamp circuit interrupted. Meanwhile, the repeated attempts at starting are annoying and seriously shorten the life of the starter.

A starter has been developed that not only provides the necessary time element to preheat the cathodes for starting, but also stops the lamp by interrupting the circuit when it becomes deactivated or reaches the end of its usefulness. This is the "no-blink" starter, available in two sizes for 40- and 100-watt lamps.

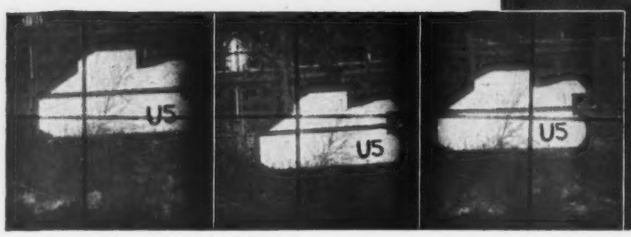
The additional function is accomplished by arranging a simple form of thermal switch in series with the starter timing switch. When the lamp is in good operating condition the starter functions normally, and merely provides the time to start the lamp. However, when the lamp fails, the starter makes a few attempts to start the lamp, and the resultant heat brings the thermal switch into operation, opens the lamp circuit, and holds it permanently open. This not only eliminates the annoying blinking, but it reduces the current flow through the lamp auxiliary and saves power. The starter is fully automatic. When the burned-out lamp is replaced the starter is automatically restored to its lamp-lighting function.

Cameras Save Bullets, Prove Accuracy

PROOF of the efficacy of a gun stabilizer does not necessarily involve actual firing to measure the hits obtained, and certainly this method wastes valuable ammunition.

Engineers who built the device for holding steady a tank gun while speeding over rough ground need an accurate means of checking the performance of the gyroscopic control. Actual firing is expensive and is not an accurate test of the stabilizer because it includes errors of gunner's judgment in allowing for windage, range, projectile characteristics, etc., over which the stabilizer has no control. So, instead, a novel photographic device was developed that not only does the trick, but also does it better.

A camera, built for taking pictures rapidly on standard miniature film, is clamped to the gun barrel. The exposures are made through a lens marked with cross hairs. As the tank bounces over the rough test course the gunner "fires" in the regular manner except that pressing the trigger "shoots" a picture of the distant target instead of firing a projectile at it. How well the intersection of cross hairs follows the target shows the combined performance of stabilizer and gunner.



To test how well the gun stabilizer holds the gun level with the tank moving, the target is "shot" with a camera. The position of the horizontal cross hair in the three typical pictures indicates the results.

With the Electrigage, errors in the lead of screws, taper or concentricity of rings can be measured to twelve millionths of an inch.

Super-Accurate Electric Gauges

ONE OF the secrets of American industrial success is mass production. The secret of mass production is precision manufacture, not only in one plant, but in many distant plants so that parts or machines are interchangeable. The precision tool is king. But behind it all stands that super-precise device, the master gauge.

One of the newest of these is the Electrigage by which the accuracy of thread gauges, threaded parts, or of a machine-tool lead screw or rack can be checked on an instrument that is graduated in fifty millionths of an inch. Readings can be interpolated to about twelve millionths of an inch. This is equivalent to finding an error of about three quarters of an inch in a mile.

With the Electrigage applied to an internal-external measuring instrument it is similarly possible to check, with the same accuracy, the outside or inside of a ring for taper, bell, or out-of-round conditions. The Electrigage, developed jointly by the Sheffield Corporation and Westinghouse, uses a mechanical pickup that has a feather touch of but three ounces. Movement of the gauging stylus alters a magnetic circuit to produce a current indication. This is amplified as much as 10 000 times and fed to a specially sensitive milliammeter with a linear scale and zero center to show plus or minus error. Power is obtained from a 115-volt, 60-cycle, single-phase circuit. An automatic voltage stabilizer prevents any voltage variation from affecting the quality of the results. The instrument is of value in production, where it is necessary to obtain readings quickly, because of its exceptionally high speed and good damping characteristics.

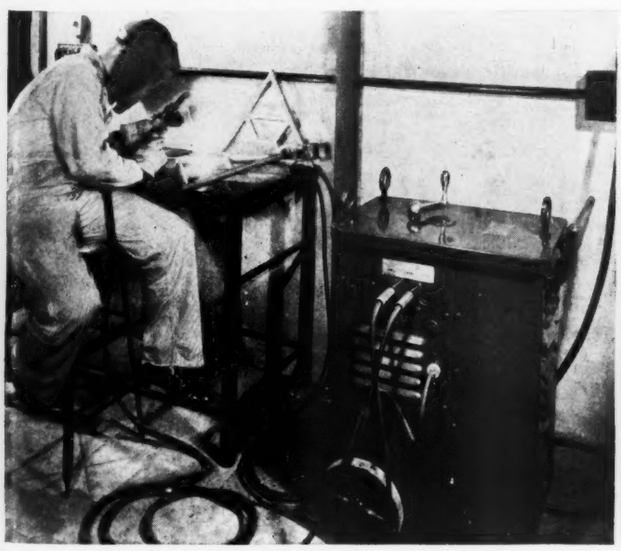
A Lesson in Diameters and Speeds

A MOTOR that runs at 60 000 revolutions per minute! That is 1000 revolutions each second. Few motors of appreciable power, if any, have ever turned so fast. Motors that rotate at such terrific speeds are the answer of research and motor engineers to a dilemma created by machine-tool builders. It is desirable in grinding, polishing, or routing metals to have a velocity of 5000 to 7000 feet per minute at the surface or periphery of the tool. This high surface velocity results in fewer deep scratches and a better finish. With large-diameter wheels, such high speed of the wheel periphery is obtained without exceptional rotational speed. For example, a one-foot diameter wheel traveling at only 1800 rpm has a linear speed of 5650 feet. To obtain the same speed with a half-inch wheel requires 42 000 rpm. Finishing the interiors of small cavities necessitates wheels of this size or smaller.

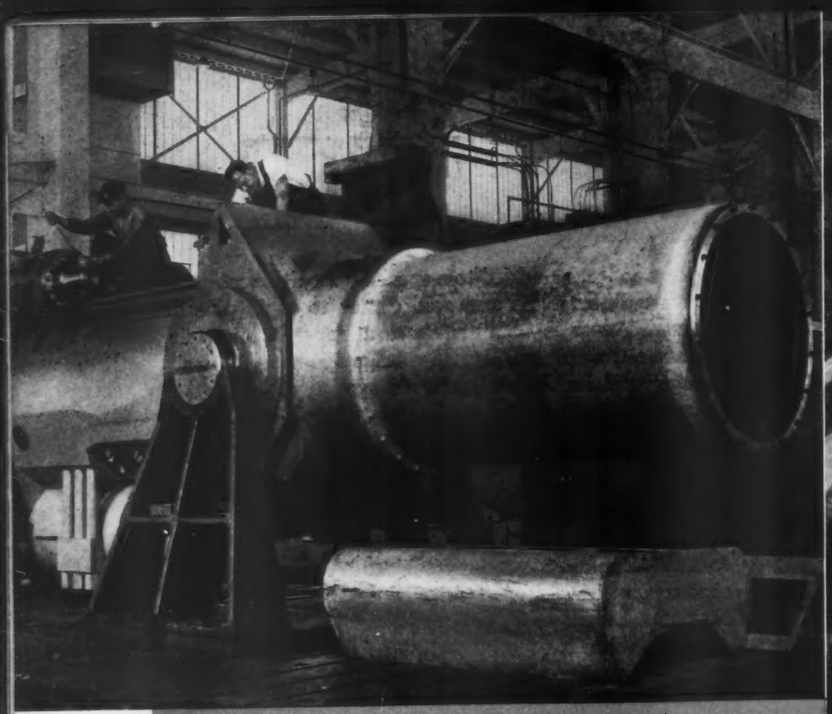
Because such high rotational velocities present many mechanical difficulties with belts and pulleys, engineers have been seeking to do this with direct-drive electric motors. Last year research work was completed that permitted construction of a 60 000-rpm motor. This is an induction motor supplied from a 1000-cycle generator and delivers four hp at this speed. The rotor is only one and three-quarters inches in diameter and two inches long. Even so, the centrifugal stresses at the surface of the rotor reach about 15 000 pounds per square inch.

This 60 000-rpm motor may soon be overshadowed by one running at twice this speed—120 000 rpm. Such a motor is still in the course of research-laboratory development.

A small current of high-frequency stabilizes an a-c welding arc.



This small motor runs at 60 000 rpm and develops four horsepower.



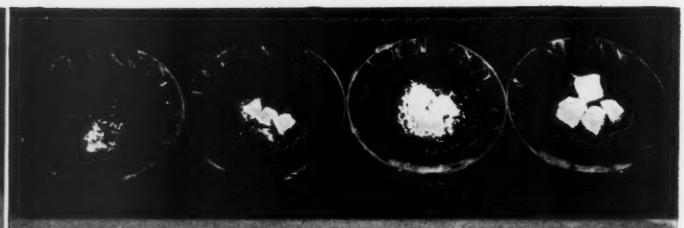
The stationary housing (above) for the recoil mechanism of a 16-inch gun itself resembles a giant cannon. The workman (right) is gauging the bore of "spoons" assembled to torpedo-tube mounts.

About 30 000 pounds of rubber were saved last year in the manufacture by Westinghouse of Army binoculars by the development of a method of applying a vinylite cover instead of one of rubber.

This young lady cultivates a garden-full of trouble for the enem... These 27-inch antenna masts for airplanes are made of Micar... They are hard, strong, and light, and save critical materi...

The electric motors that drive the gyroscopes of the famous American bombsights must be balanced with great precision (above). This work required rebuilding the already super-accurate electronic balancers to increase their accuracy by approximately eight times. These four-inch diameter flywheels, overhung from the armature shaft, almost surround the motors that drive them.

...se of a-c welding (right) is encouraged by a transformer-...welder (above) that weighs 200 pounds instead of 320 and ...pies 256 square inches of floor space instead of nearly 500.



Studies of clothes rinsings by the usual laundry techniques indicate a continuous build-up of unremoved solids. The first tray shows the ash (unrinsed solids) of a specimen of white cloth after one rinsing; the fourth tray, the great increase in ash after 100 washings.

How Clean Are Clean Clothes?

A WHITE shirt after 100 careful washings may contain fifty times more unremoved solids than after the initial wash. This cumulative build-up of insoluble residues—indicating incomplete rinsing—is but one of the surprising facts uncovered in an intensive research into laundry methods.

With materials and man-hours not available for extensive development of improved washing equipments, laundry engineers elected to use what time can be spared from war work to determine scientifically the mechanics and chemistry of the washing of clothes. Much of the study is directed to the rinsing of clothes because it has been the most neglected phase of washing. Mechanisms for washing clothes have reached a high peak of development. However, with the coming importance of automatic-cycle washing, the matter of thorough rinsing of the clothes in shortest time and with least water consumption deserves attention.

The previous and obvious method of checking rinsing efficiency has been to compare chemically the water after rinsing with the fresh-water intake. This has been found not to be a sound procedure. Soaps combine with the calcium and magnesium salts in the water to form insoluble solids or curds. These must be swept out of the fabric mechanically by the water instead of being carried away in solution, and unless the process is done well, the used rinse water may show no trace of the hidden undesirable solids. As a matter of fact, a thorough rinsing entails the same washing and flushing action in clear water to remove the insoluble solids as was necessary to remove the original dirt. The residue in certain chemical combinations with the soap is sometimes as difficult to remove from fabric as the dirt itself.

A new laboratory method has been devised for determining precisely the effectiveness of a rinsing technique. A fabric is successively washed and dried many times. After each washing a sample is cut from it and burned. This removes all of the organic substances and leaves as an ash the oxides of the inorganic substances originally present in the curds. This ash is weighed on an analytical balance and the total is an accurate measure of the effectiveness of the rinsing technique used.

Make It Last Longer

OBJECTS that cannot be replaced, such as tires, the old family bus itself, waffle irons, electric roasters, or washing machines, assume enormous value. Now that they cannot be replaced, the ability to have them repaired takes on an importance unknown in the days when only a half-hearted interest was taken in getting them fixed because new (and better) ones were so cheaply available. To stretch the life of these indispensable home aids, appliance engineers have applied the ingenuity that was previously directed so intensively toward making new and better appliances. As a result, in thousands of homes, the appliances—that in ordinary times would be rusting in the scrap heap—are continuing to give service for the duration.

The electric iron is a good example. An important and basic part of the conservation program was to train a nation-wide group of new service men and women to make repairs and use the alternate materials for original repair parts no longer available. This enabled the new "army" of service workers to keep appliances in good working order by repairing them in the customers' home town.

Electric irons of modern design have a rubber sleeve around the cord as it enters the heel of the iron to prevent bending of the cord sharply. Rubber is no longer available for this use. For irons on which this sleeve needs replacement a wood bushing with smoothly flared entrance is used, which serves the basic purpose of the rubber sleeve equally well. The prewar thermostat knob of the electric iron was made of phenolic plastic. The present alternate is one of cold-molded material, which, to be sure, is slightly bulkier but is just as serviceable. Because nickel, the corrosion-resisting undercoat for chromium on the base of electric irons, was no longer available, it had to be omitted during the last few weeks of iron manufacture. A special wax coating was devised to place over the chromium to protect it until the iron is placed in service in the home.

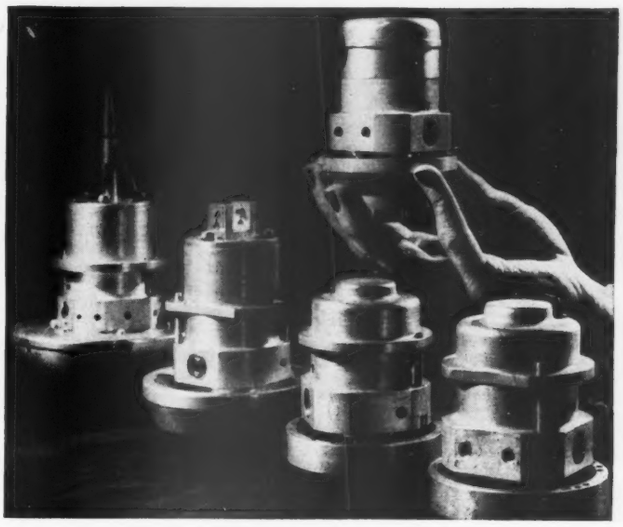
Those delicious waffles that "mother used to make" were probably turned out on cast-iron grids. Modern irons have the lighter grids of die-cast aluminum, no longer obtainable. However, by making replacement grids of cast iron, hundreds of families have the pleasure of service from their waffle irons that would otherwise be laid up for the duration.

When WPB stopped the use of materials for new electrical appliances, manufacturers had a problem of making the "bread and the butter come out even." Thousands of appliances could be made available if all parts in stock could be used. With electric irons, for example, the stock of covers was shortest. Engineers devised a cover of enameled iron instead of chromium-plated steel. This alternate has given excellent service and permitted some 50 000 more irons to be made available. Likewise, using cast-iron grids permitted 60 000 more new waffle irons, without waste of strategic materials.

Hundreds of electric ranges of a certain type have been saved from retirement for the duration simply because engineers found a small stock of magnesium sheet of an obsolete size and quality in an aircraft factory. Range heater elements consist of the resistance wires embedded in an oxide of magnesium. This is done by wrapping metallic magnesium around the resistance wires and reducing it by heat to the oxide. Metallic magnesium is needed elsewhere, so this second-grade or otherwise waste magnesium saved the day, although its use entailed seemingly insurmountable manufacturing difficulties because the magnesium was harder than had been used.

Many other ingenuities are being employed to keep the appliances of the home front in action. Thermostats, previously discarded instead of repaired, are now disassembled to create a stock of parts from which good units can be assembled. Roaster covers are made of enameled steel instead of pressed stainless steel.

In some cases the alternate is as good as the old; in others it is admittedly not as good, but the sacrifice generally lies in appearance or weight and not in performance—which, after all, is the important thing.



Here are only a few of the many varieties of gyroscopes and their electric motors. They are all built to perform important war jobs.

Tiny Motors That Put Gyroscopes to Work

GYROSCOPES are of major importance in this war. They hold guns steady for firing in spite of the diverse movements of the vehicles; they are a part of bombsights; they help steer torpedoes; they help scan the sky for evidence of the enemy; they serve in compasses and in many other devices. To drive these fascinating gyros at their high speeds of several thousand rpm has required many special electric motors.

One, for example, is called upon to bring its gyro flywheel to full speed of 12 000 rpm in two-tenths of a second. This motor —about the size and shape of a beer bottle—weighs but 10.5 pounds, but develops 22 hp. To get the 600 amperes into the armature, the brushes must work at the very high current density of 1600 amperes per square inch.

Another gyroscope required a motor of super-accuracy. To insure absolutely vibration-free operation the weight must be almost perfectly distributed. To balance these rotors required building special dynamic balancing machines using the Westinghouse Dynetric principle. These were eight times more sensitive than Dynetric balancers ordinarily used in precision work. These machines are able to detect an excess or shortage of weight on the five-inch diameter flywheel of one ten-thousandth of an ounce. The balance of these wheels is so sensitive that a tiny burr on the balance screw will affect the operation. The machining and balance are such that the trueness of the whole system is of the order of one millionth of an inch with respect to the bearing. All parts are made on a production basis and are completely interchangeable. To do this it is necessary that all finishing operations be performed in temperature-controlled, dust-free rooms. These tiny motors, with armatures only a little larger than a wine glass, bring the flywheels up to 1600 rpm in about 40 seconds, and after power is shut off will coast for more than one-half hour.

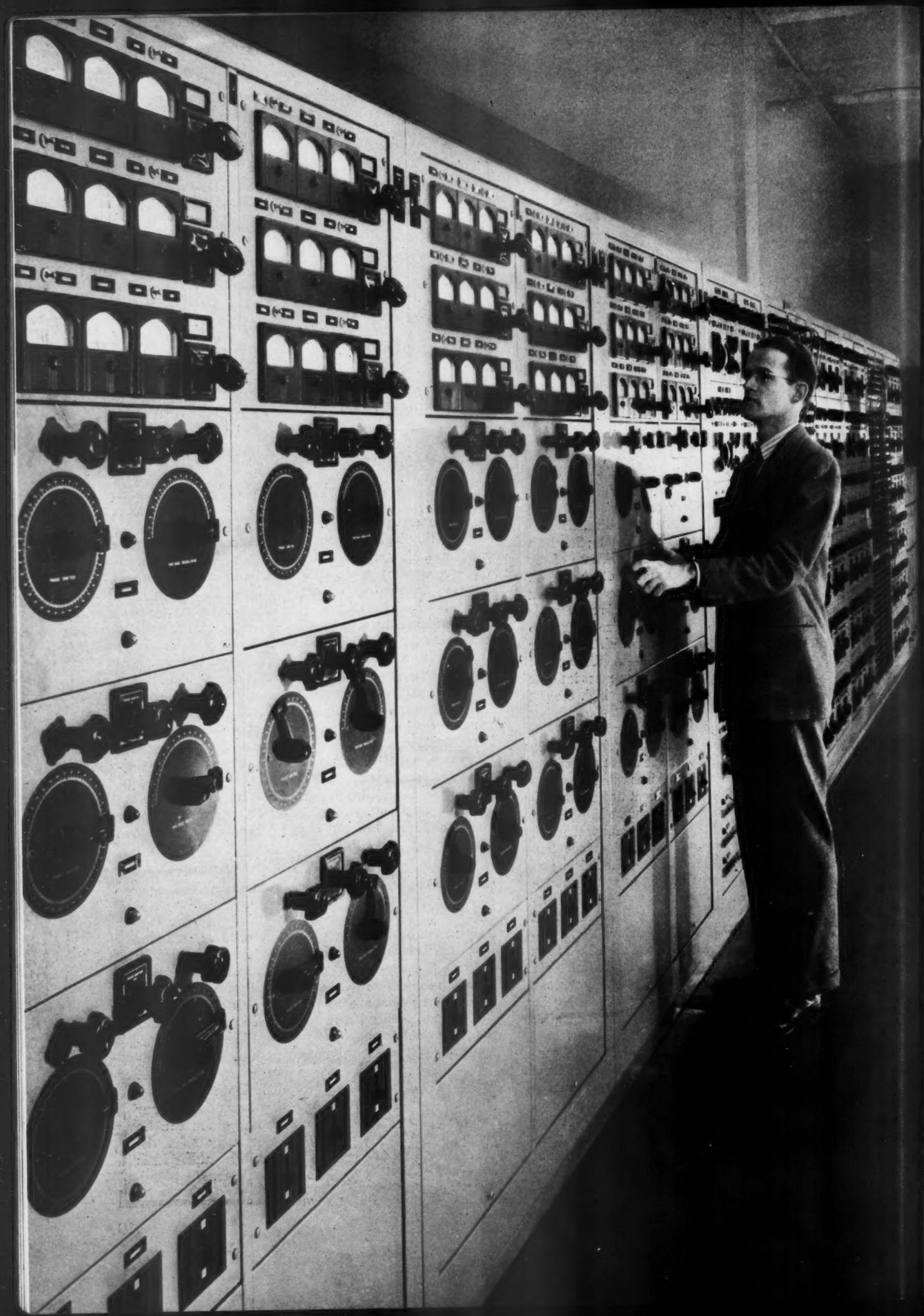
Other bantam gyroscope motors include several that consume but three watts (about 1/250 hp). The rotors for these baby motors—including commutator and shaft—are about the diameter and length of a thumb. One d-c shunt-wound, 24-volt motor drives its gyro wheel at 14 000 rpm. Two others, although no larger than a man's fist, are supplied with three-phase current, one at 240 cycles (14 000 rpm) and another at 400 cycles (12 000 rpm). The 240-cycle motor with a rotor less than one inch in diameter and less than one inch long carries a four-pound flywheel. Still another is a single-phase, capacitor-type, 3400-rpm, 60-cycle motor having an output of about one watt (1/750 hp).

These tiny high-speed motors must operate under trying conditions. They must be able to start their high-inertia loads with the temperature at 40 degrees F below zero and run continuously with outside air at 130 degrees F. This makes a severe lubrication problem, especially considering that the space for lubricant is small. The motors are totally enclosed and are contained in tight housings with other heat-producing apparatus so that the temperature problem is doubly aggravated. Without the use of special low-loss iron for a-c stators and d-c armatures the motors would literally burn up.

As with their larger companions, the tiny gyroscope motors must be precisely balanced—and must retain that balance. Because ordinary varnish might soften at the high operating temperatures and deform, destroying balance, special thermosetting varnish is used that won't shift when hot. Even the standard progressive winding cannot be used in the d-c armature because it does not distribute the mass of copper around the rotor with sufficient uniformity for the precise balance required at these high speeds.

Life-Saving Lamp

FLYERS bobbing around on a rubber raft at sea now have much better chance of rescue because of a new lamp. It is a small lamp, slightly smaller than a golf ball, with an internal silver reflector so that no lens or external reflector is needed. It fits into a socket on a head band, which leaves the man's hands free. The six watts it burns is furnished by a hand-cranked generator. The lamp projects a 1500-candle-power beam, which can be seen many miles depending on atmospheric conditions.



POWER GENERATION, DISTRIBUTION

On casual examination, progress in power-generation and distribution equipment would seem to be one of the casualties of the war. The parade of power-generating units of record-breaking size has stopped. In fact, almost no major additions to steam-plant capacity are under way. Few new high-power lines are built, except as system ties or to serve some power-short war-industry area. However, true progress in engineering is not measured by records broken or by the list of new installations. These are but manifestations of the fundamental gains—new principles, new materials, materials with higher limits, new design or manufacturing techniques. And, of these there are plenty that can be put to work by designers of turbines, generators, breakers, transformers, arresters and all the other members of the power family. Meanwhile we can look at a few of these fundamental engineering advancements.

Relay Gives Protection to Long Lines

DISTANCE relays that protect electrically long transmission lines must be able to distinguish between load impedance and fault impedance, i.e., between a legitimate load and a fault. Generally, the fault impedance is so much smaller than normal load impedance that the relay has no difficulty in discriminating between the two. But if the line is long and the load heavy—as is becoming more common, what with wartime power loads, more interconnections, and longer lines being built—the impedance in a short circuit may be actually greater than the impedance resulting from full-load current flow. Then the standard impedance relay operates incorrectly during full-load conditions. Furthermore, the relay should not operate on surges that will not result in loss of synchronism. The relay therefore must be provided with some different sense of perception, so that it will trip for faults but will not trip for any other system conditions, load, or surges that will not pull the system out of step.

A new long-line relay has this discriminating ability, making use of the wide difference in phase angle that usually exists between load and fault currents on electrically long circuits. Load currents on long lines generally are near unity power factor, and fault currents lag by 60 degrees or more. The relay for this job is the high-speed impedance relay (HZ) with its characteristics modified to recognize not only the magnitude of an impedance, but also the impedance angle.

New Turbine Blade Ends Four-Year Search

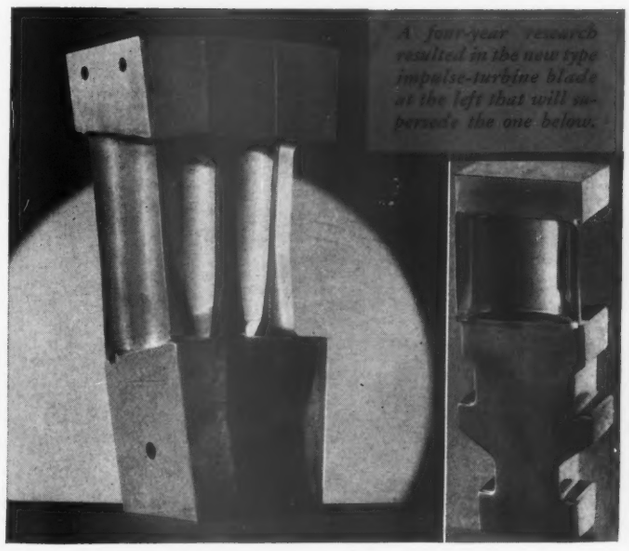
ALMOST overlooked in the engineering news last year was this unimpressive statement: "The studies of turbine impulse blades begun by Westinghouse engineers four years ago have been completed." A great deal of engineering drama and much of peacetime significance lie behind those words.

The middle 30's saw the size of high-speed (3600-rpm) steam turbines for superposition over existing units in power houses being rapidly increased. In three years the largest size of this type was extended from about 15 000 to about 50 000 kw. Steam engineers in crossing these new frontiers found themselves faced with new conditions. Impulse blades made correspondingly stronger according to previous practice were not strong enough. Established design rules no longer held in the new regions of greatly increased temperature, pressure, and vibration.

A long and painstaking program of theoretical and laboratory studies was begun. A special test turbine was built, and a unique scheme was devised for taking photographic records of blade behavior while the turbine was in actual operation. In this four-year study several types of blades have been tested under a wide variety of temperature, load, and speed conditions. Long endurance runs have been made. About 120 000 photographic records were taken on about six miles of film.

Out of this enormous mass of engineering data has been evolved a superior, yet very simple impulse blade. The root by which it is fastened to the turbine rotor is shaped like an inverted U. Three of these blades are brazed together, forming one solid segment. Each three-blade segment is fastened to the rotor by two crosswise pins (not shown in the illustration below).

A measure of the merit of this new blade is its comparison with the best previous blade. The new blade is smaller than the old one, 1½ inches wide instead of two. Whereas the old and larger blades failed in the turbine in less than 20 hours, the new blades pass the life test of 1000 hours with no indication of weakening. Experience shows that if a blade will fail at all it will do so in relatively few hours. Thus fortified with a great deal of new design information about impulse blades, turbine engineers are ready to move to new levels in turbine construction when the central-station industry needs—and is able to obtain—larger and more powerful high-speed power-generating units.



A four-year research resulted in the new type impulse-turbine blade at the left that will supersede the one below.

...uch enlarged and greatly improved a-c calculating board makes it pos-...e to solve complicated power-system problems more quickly than on ...ious calculators. The board can simulate up to 18 power sources, and ... be electrically divided in any desired manner for the simultaneous ...tion of two small problems, or it can be operated as a single unit for a ...e-system study. Instrument scales read directly in power-system quan-...s instead of requiring the use of multipliers, which simplifies the work.

New potential transformers use but one eighth as much oil and weigh two fifths as much as their predecessors.

Potential Transformers Shrink

POTENTIAL transformers, too, keep in step with the general trend to smaller sizes and lighter weights for electrical apparatus. Potential transformers of a new family, which extends from 25 to 138 kv, are but midgets compared to their predecessors. A typical example is the 69-kv unit illustrated above which is only two-thirds as tall as formerly, requires less than one-third the ground space, and one-fifth the volume. These reductions are made possible chiefly by the use of Hipersil steel and by a new type of bushing that uses a highly insulated lead through a suitable weather casing. Closer coordination of insulation structure coupled with design features that permit liberal substitution of non-metallic materials for structural and supporting members are no less important.

Power Follows the Rails

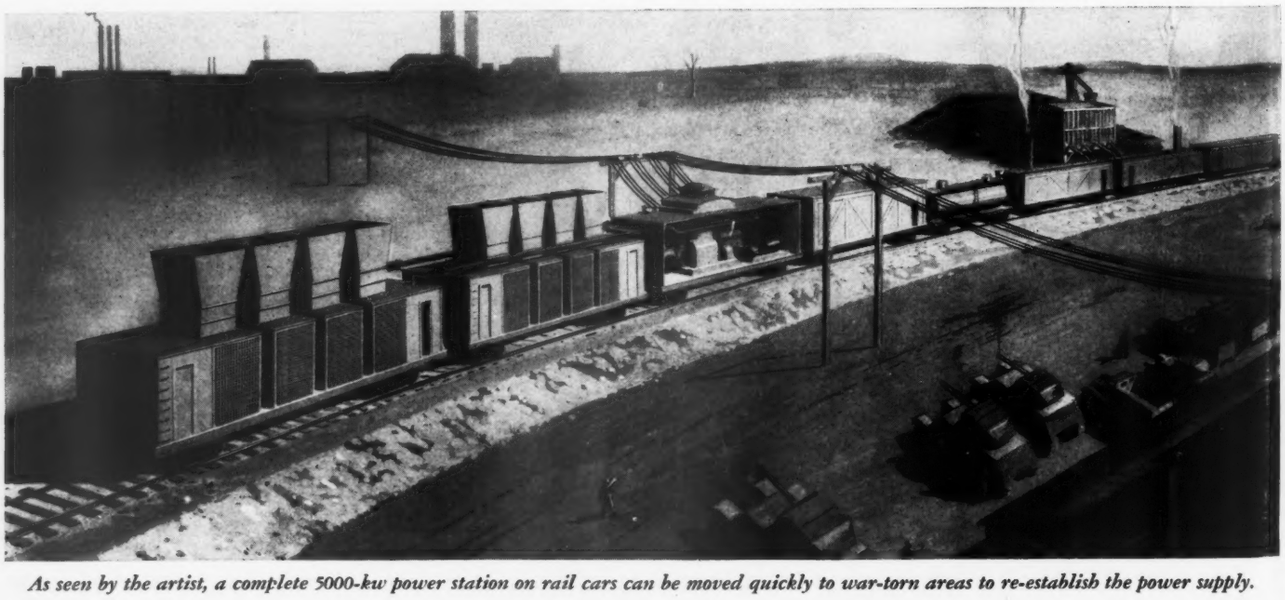
IN THIS war of rapid movement even electrical power stations become as mobile as the traditional Arab and his tent. A complete 5000-kw central station has been designed as a railroad train of eight cars. This power train is suitable for use in almost any part of the world. It has been designed to use coal of unusually low quality, for arid or devastated regions where water may be so scarce it would have to be brought in in tank cars, for temperatures of heat and cold ranging from 110 degrees above to 40 degrees below zero F. This rolling power plant can be hauled by a locomotive to any spot where railway tracks exist and in about 48 hours be set up ready to deliver power to the bus.

In wartime such power trains can follow victorious armies into recaptured areas to rehabilitate local industry, or conversely—although not such a popular idea—can be removed from areas about to fall into the hands of an advancing enemy. Also, these trains have a peacetime application as the power supply for flooded plants and in similar emergencies.

Beginning at one end of the train, the first two cars carry the air-cooled condensers; the next the turbine generator with switchgear equipment; followed by cars for auxiliary equipment, water storage (that will run the train under most severe conditions for more than a full day without replenishment), two cars for the boilers, and the eighth car for crew quarters with storage for some miscellaneous necessities as lubricating oils, spare parts, etc.

The two boilers produce steam at 600 pounds gauge, 750 degrees F from available coals, even from lignite having a heat content of 7000 Btu per pound. The boilers are of water-tube, double-drum construction, have both forced- and induced-draft fans, and air-operated locomotive-type stokers. The single turbine-generator unit delivers to the bus 6250 kva at 80 per cent power factor, 6300 volts. This power is delivered to a six-cubicle, metal-clad switchgear for distribution. Because the intake ventilating air may be dusty or dirty the generator is provided with a self-cleaning air filter. A Diesel-driven generator provides 75 kw for the plant, and for auxiliary purposes.

The power train is camel-like as to water. In many places where a rolling power plant is needed, cooling or boiler water may be virtually non-existent or of poor quality. To meet this



As seen by the artist, a complete 5000-kw power station on rail cars can be moved quickly to war-torn areas to re-establish the power supply.

Model of a substation that can be used wherever power lines and railroad tracks come together.

condition the condenser is air cooled and the condensed steam is reused. In each of the condenser cars four motor-driven propeller fans draw air over eight coolers. Even with the cooling air as warm as 95 degrees F the condensers are able to condense the full amount of steam. The condensed water is pumped back to the feed-water tank car. By this method it is expected that less than three per cent make-up water will be required. All make-up water is filtered, softened, and evaporated in the auxiliary car.

Shoehorning a modern 5000-kw plant into a train of eight cars presented scores of engineering problems. The trucks had to be made specially rigid so that no torsional movement of the frame in transit ruptures pipe connections. All apparatus—meters, shafts, gauges, etc.—are braced so as not to be injured by a sudden stop of the train. Pipe and electrical circuits between cars are disconnected while the train is en route, which calls for means of aligning the cars preparatory to going into service. Because of the very tight fit in the turbine-generator car, for example, the sides of the car are removable to give access to the generating unit should dismantling be necessary. This leaves no supports for a crane, overhead piping, or conduit. These necessary supports are all built up independently from the floor. Because the train must be capable of operation in air 40 degrees below zero F or 110 degrees above, many problems of unequal expansion throughout the entire train had to be anticipated.

A Substation Where and When It Is Needed

ELECTRIC power, engineered to meet immediate needs, is available in a portable substation—a complete substation that can be taken anywhere on any railroad system at a moment's notice. Mobile stations have usually been mounted on automotive trailers. These stations have demonstrated that they have the same high degree of reliability that is found in modern stations of conventional design. Railway-car mounting is a further development of mobile-substation equipment.

These high-voltage substations, engineered to meet the requirements of the system to which they are to be connected, are entirely self-contained and can be quickly taken to any point where railroads are available. The total time required for location is that taken for transit plus time to make the necessary mechanical and electrical connections.

The complete substation is contained on a standard railway flat car. It has all of the switching, transforming, distributing, and protection features of a modern conventional transformer station. These include a three-phase transformer, high-voltage disconnecting switch, oil-circuit breaker, lightning arresters, and a set of low-voltage switchgear complete with several feeder circuit breakers, control, and protective relay equipment. The main power transformer is of shell form construction with forced-oil circulation and air-blast cooling. The shell-form core, when laid on its side, provides additional strength and stability to withstand the vibration and shock accompanying rail transportation.

An ingenious turntable mounting for the high-voltage circuit breaker and a hinged collapsible structure for the high-voltage disconnecting switch, allow full electrical clearances to be maintained between phases and to ground when the substation is set up for operation, without exceeding railroad clearances when in transit.

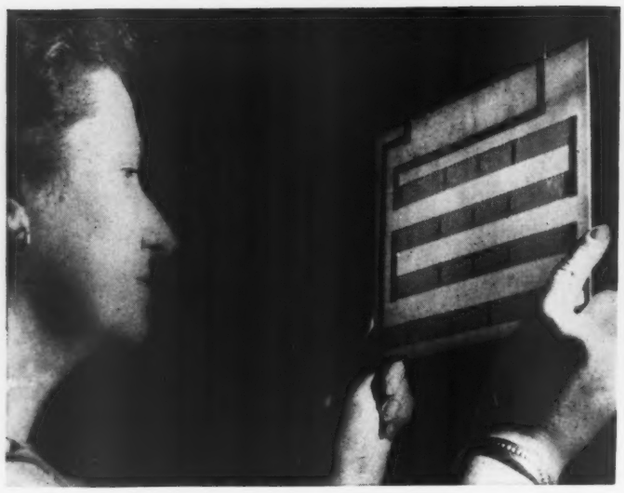
The high-voltage incoming lines can be dead-ended to the line insulator stack of the disconnecting switch and the low-voltage lines can be connected to the low-voltage switchgear by cable or directly to low-voltage roof bushings, thus eliminating all special masts or structures on the car.

The railway-car mounted portable substation enables power to be taken from a system at any point where transmission line and railroad right-of-way are close together. It meets the four major requirements for this type of service—mobility, flexibility, simplicity, and economy.

Instrument Glass Covers Are Now Cemented

SYNTHETIC cement now replaces putty as a means of holding instrument windows in place. The glass covers have long been puttied in, like windowpanes in a sash. Much time is consumed in removing the putty smears from the glass—a laborious hand operation. After extensive research, a synthetic cement has been found that seals the glass to the plastic instrument case far tighter than any putty. A simple, automatic machine paints a narrow band of the cement on the rim of the plastic case, the glass is pressed in, and the cement is set in a few minutes in a low-temperature oven. No cleaning of the glass after cementing is necessary.

AN UNUSUAL *speed reduction problem was to provide a gear drive having one input shaft operating at 17 000 rpm, with five output shafts, each operating at a different speed. These output speeds range from 1263 to 2500 rpm respectively. Limitations in space made it necessary that the gear unit not exceed 9 inches in length or width, or 3½ inches in depth. The gear units were produced in accordance with all specified requirements and passed all prescribed tests.*



This Micarta-encased resistance heater will keep a battery warm. At sub-zero temperatures batteries may be able to deliver only one-fourth their normal power. Heaters installed between battery units or inside the cells themselves keep them at an efficient temperature.

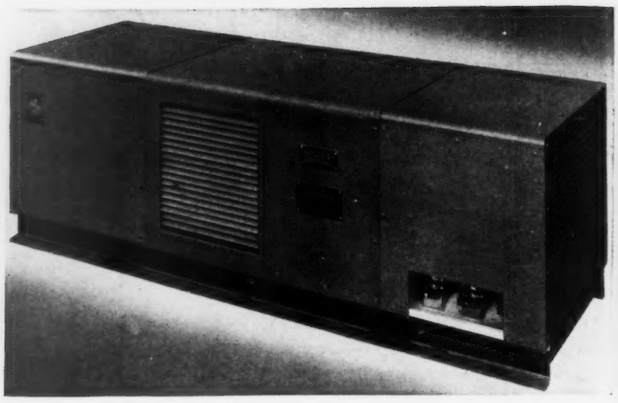
More Output from Air-Cooled Transformers

"GET MORE out of what we have," has been the wartime rule. A new method of increasing the power available from air-cooled transformers is an example. Air-cooled units—developed a few years before we were plunged into war—have been a godsend to thousands of war factories. They have carried loads corresponding to their name-plate rating for long periods. On occasion, plant engineers have elected to overload them for short periods, utilizing the inherent extra capacity available if the actual ambient temperature is low or if the overload is short lived. However, the engineer has no means of knowing exactly how much extra load can be carried safely.

Now, new Westinghouse air-cooled transformers can be fitted with a device that makes available from these transformers all the load capacity down to the last watt with safety to the insulation. And it does so without requiring any attention of the plant engineers. This device, called a TRA relay, permits "loading the transformer by copper temperature." It takes into account ambient and winding temperatures and how long they last, as well as what load the transformer had been carrying when the overload arrives. It does this through bimetal elements actuated by changes in temperature of air stream and by the current from the secondary of a current transformer. Thus, the TRA relay controls loading of the transformer on the basis of both time and temperature, permitting the maximum safe temperature of the windings themselves.

The Rectifier That Came to Dinner

THE WAR is replete with examples of things done under the pressure of the emergency that have proved so satisfactory that they will stick. Power supplies for ship-to-shore radio sets are an example. Motor-generator sets have customarily been used to supply the three or four d-c voltages. Early in the conflict, rotating machinery became a serious

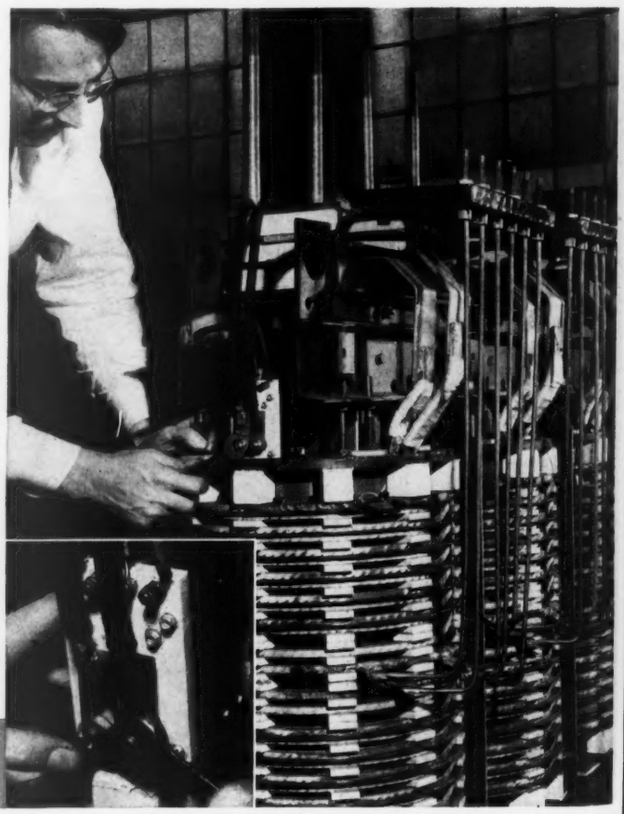


The appearance of this apparatus gives no hint as to its purpose. It is a copper-oxide rectifier built to the same shape and dimensions as a motor-generator set, which it could quickly replace on shipboard.

production bottleneck with long delivery dates. The Navy turned to copper-oxide rectifiers of the Rectox type as an alternate because they were more quickly obtainable.

Several sizes up to 5½ kw were developed, using high-voltage, low-current type discs. They are forced ventilated by a small fan. The designers, borrowing an idea from electric-motor engineers, protect the apparatus with Thermoguard-type thermostat. A low current passes continually through the thermostat. While the ventilating air continues to flow over it the contacts do not open. However, stop the ventilation, and the Thermoguard acts quickly.

One version of the rectifier takes the unusual horizontal form. It is built of such shape and dimensions that it could be substituted quickly for a damaged m-g set. It has the same output as the rotating power supply and meets the Navy's re-



The small unit in the inset is a relay mounted in air-cooled transformers that enables them to carry maximum load with safety.

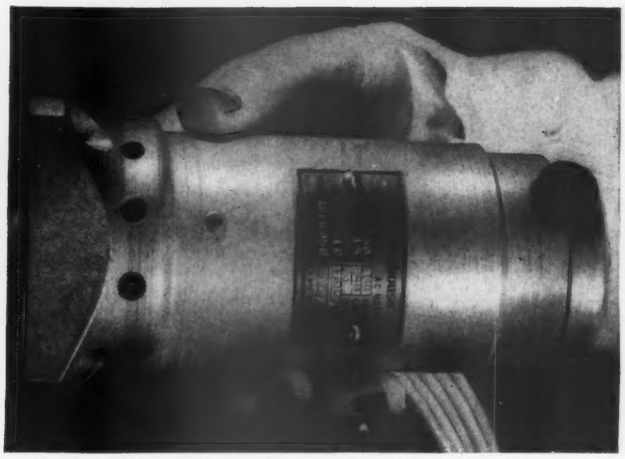
The dynamotor is the direct-current "transformer" used by the thousands to provide the several constant d-c voltages required by radio equipments. This one, dubbed the "Flying Tiger," is unusual in that it delivers three voltages and therefore must have four commutators.

quirements for vibration, shock, and tilt. Its electrical characteristics are entirely satisfactory. It requires somewhat less maintenance than rotating machinery and—what started it all—is quicker to build.

Chicks Get a Better Start in Life

SIXTY per cent of chick mortality occurs within the first 16 days, because the newly hatched chicks are crowded together in warm, humid rooms so that any infection of one spreads like a flame. Sterilamps installed during the past 18 months in several hundred large-scale poultry farms have greatly reduced this mortality with its attendant food loss. In one test installation where close check was made, the mortality was reduced to less than one third. Furthermore, the number of culls in the irradiated building was reduced, and the birds grew faster, reaching in five weeks a weight previously attained in eight.

Protective relays and knife-blade test switches have been combined in one compact case—the Flexitest case. To remove the relay from its case requires but the release of two latches, and pulling the chassis forward. All relay connections are through knife switches.



A handful of motor-generator set! Built for a new military control device this delivers but 15 watts at 35 volts from 240-cycle power.

Tom Thumb Motor-Generator Set

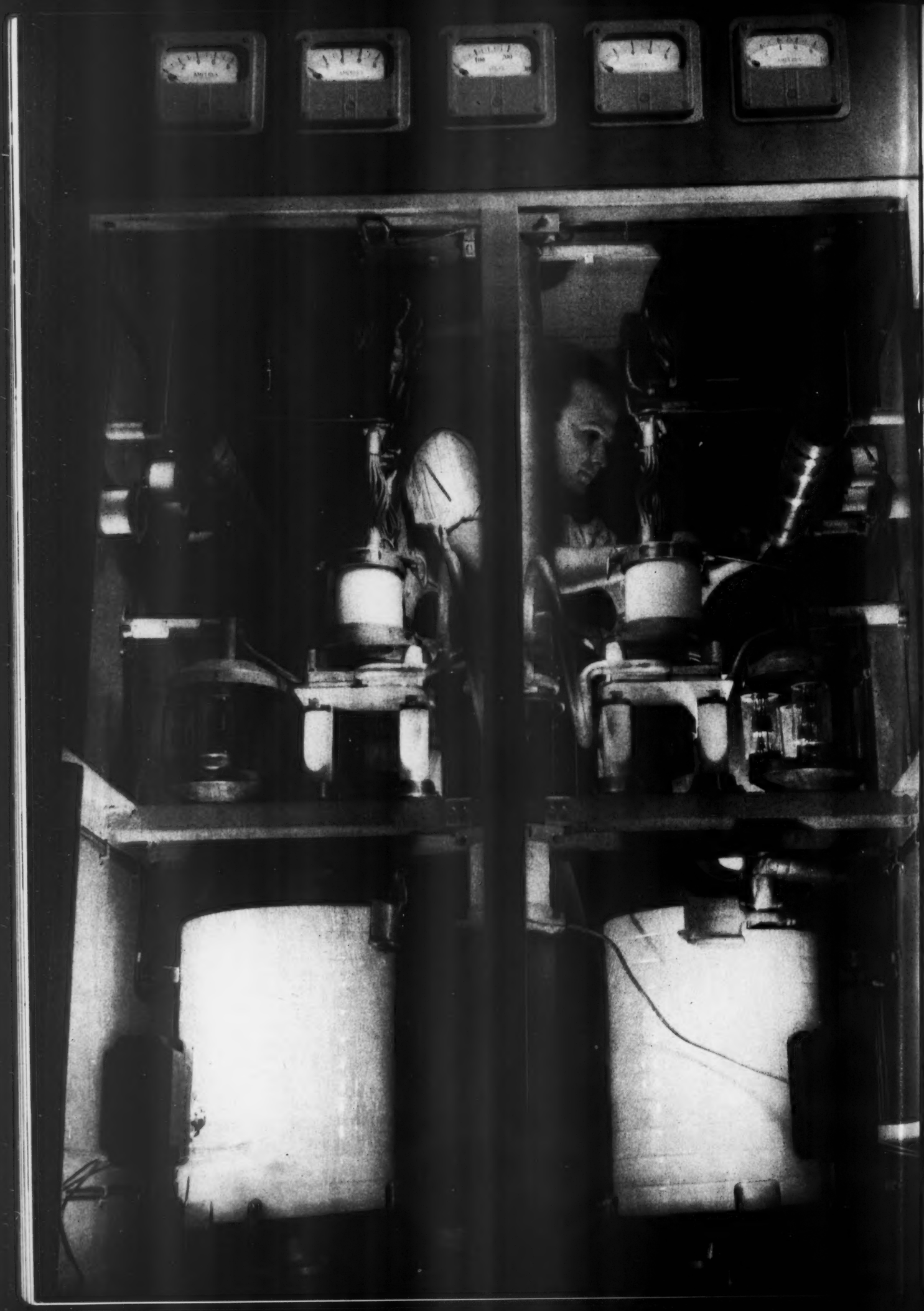
A CLAIMANT for honors as the smallest motor-generator set is one that could easily fit inside a water tumbler. It was created to provide variable-voltage direct current to a secret gun-control device.

The motor of this midget m-g set operates on a 110-volt, three-phase, 240-cycle circuit, and being a two-pole motor, has a synchronous speed of 14 400 rpm. The rotor is approximately one inch in diameter and about ⅞ inch long. The generator armature is approximately the same size. Both rotor and armature are assembled on the same shaft with a ball bearing on each end. The tiny generator delivers a maximum of 15 watts at 35 volts.

Because of the high frequency, 240 cycles, on the motor stator and the high speed of the generator armature, special low-loss electrical sheet steel is used in each to keep the losses and heating to a minimum.

A Four-in-One Dynamotor

USUALLY a dynamotor has a single, or perhaps two, output voltages. A new one, now used in large numbers, is unusual in that it provides four closely regulated voltages, +14½, −150, +300, and a maximum of 450. This entails four separate commutators, and poses serious problems in taking the connections to the outer commutators through the inner commutators. Ordinarily the output voltage of a dynamotor bears a fixed relation to the supply voltage. But in this case all output voltages are held constant for all normal input-voltage variations by a regulator field, which weakens when the input voltage rises and strengthens when the voltage drops; the regulator acts on a separate core. The complete armature has four commutators, two cores, and four windings —in a total diameter of 2.8 inches and length of 11 inches.



ELECTRONICS DEVELOPS RAPIDLY

Electronics has developed with great rapidity from a term generally related to radio and telephone communication and a few industrial tube uses to one signifying a large and major branch of the electrical industry. The war, by its enormous use of electronic equipment, is responsible for this sudden crystallization. And it is the war that restricts open discussion of developments in the electronic field. The developments in electronics are manifold. The vacuum tube is the heart of electronic equipment, and in recent months many new types of tubes and tubes with greatly increased power outputs have been developed. A research into the true mechanism of electron emission has thrown new light on one of the most fundamental aspects of electronics-cathode emission. A new type of electronic control makes it possible to operate a d-c motor, with its wide speed range, from a-c lines. Electronics is no longer a matter of a few watts or kilowatts. Nearly 10 000 kw of induction-heating equipment for flowing of tin on tin plate for food cans have been placed in service in the past twelve months. Electronics is big business!

A Molecule Sorter in Industry

MOTHER'S method of making a cake was to take a cup of this, a few pinches of that, add something known only to herself, and place the mix into the oven. Usually the sole measure of her work as she went along was a few broom straws to test the creation for completeness of baking. But in modern refineries and chemical plants, a "pinch" too much of this or that is serious. The more so because many products are made in continuous processes. If something is in error thousands of gallons or hundreds of tons of material are spoiled if correction is not made speedily. In the case of high-octane aviation gasoline or synthetic-rubber constituents, such an error is almost a national calamity.

Productions of high-octane gasoline, butadiene, or styrene are precise and critical processes. They are laboratory-accurate processes on a huge scale. They need controls that are both precise and rapid. And from the Westinghouse Research Laboratory comes a new control mechanism that is both. Previous methods of making chemical tests in an oil refinery, for example, have been laborious and required several hours to complete. With the factory-edition of a mass spectrometer the check can be completed in a few minutes.

The mass spectrometer, long used in laboratories, particularly in explorations in the field of nuclear physics, is a means of determining both qualitatively and quantitatively the constituents of a gas. Especially with substances that are alike chemically and differ only slightly in weight, chemical analyses are extremely difficult. With the mass spectrometer, a small quantity of the gas—it need be only a thimbleful—is ionized by impact of electrons from a hot filament in an evacuated tube. The stream of charged molecules is drawn along the tube into a strong magnetic field, where it is bent into an arc-shaped path. The heavier the ion, the larger the radius of curvature of its path. As a result the charged molecules emerge from the field at slightly different locations —all of any one kind of particles present leaving the field at one particular spot. By collecting successively the different charged molecules at an exit slit into a current that can be amplified and measured, the constituents of any gas can be determined in both kind and proportion.

The mass spectrometer as built for use in refineries, chemical plants and similar locations is a self-contained tool. No power supply other than 110 volts, 60 cycles is required. The instrument is extremely sensitive. It can measure ion beams of as little as one billionth of one microampere. (The average antenna current of the home radio is at least one microampere.) The device can readily detect, for example, the presence of one part of oxygen in 10 000 parts of nitrogen.

The mass spectrometer is expected to have many industrial uses, such as checking the gases in protective-atmosphere furnaces, checking the completeness of evacuation processes, or as a detector of the presence of an impurity.

With the mass spectrometer a mixture of gases can be quickly analyzed.

oscillator, resembling one in a modern radio station, is used Westinghouse laboratory for experiments with high frequencies.

Electrons Measure Dew Point

TO detect the presence of unwanted oxygen and water vapor in heat-treating atmospheres, the gas is passed over a cool surface, and the temperature at which condensation occurs is noted. This temperature of condensation, the dew point of the gas, varies between —40 and —70 degrees C, depending upon the requirements of the process. Even skilled operators differ in their estimate of the dew-point temperature when it is of the order of —40 degrees C or lower. Also,

this process is not continuous. It requires that the operator take samples of the gas periodically and perform the test.

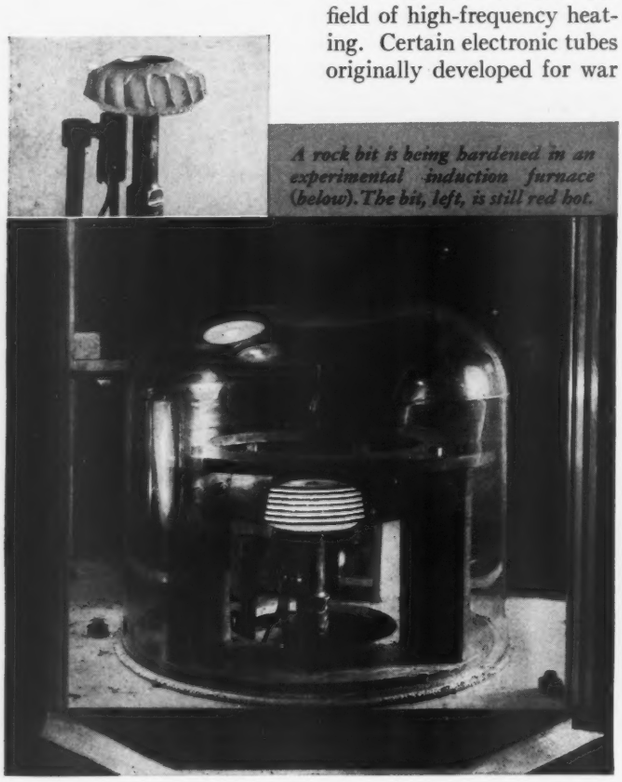
In an experimental device, electrons now do the detecting, and they furnish a continuous report of their findings to the operator. The scheme devised in solving the problem of how to detect the presence of oxygen and water vapor is based on the fact that these are ionized by electron bombardment, whereas the desired constituents of furnace gases are not. Building on this fact, a device was developed by research engineers whereby a sample of the gases is drawn past an electron gun. As long as the gas is free of the impurities the electron current is constant, but when oxygen or water vapor are mixed with the gas some of the electrons are utilized in forming negative ions. This causes a measurable decrease in electron current.

Most electron tubes are vacuum devices. This tube is essentially a diode tube but operates with both ends open. The electron emitter and the plate continually operate in a stream of hot furnace gases.

This electronic dew-point indicator removes the difficulty of judging visually determined dew points, a method subject to considerable variation. Furthermore, it provides the indication continuously. This device at present is strictly a laboratory instrument and is not commercially available. The applications of this dew-point indicator are expected to be restricted to certain types of furnace gases.

High-Frequency Heating Advances Steadily

MANY promises have been made about the peacetime benefits that are to result from wartime electronics. But little that is concrete has been said, which is natural in view of the secrecy that has veiled electronic developments and considering the lack of time available for anything but direct war work. In spite of this, one conspicuous peacetime benefit can be named. It lies in the field of high-frequency heating. Certain electronic tubes originally developed for war applications have made it possible to establish an economical and complete family of practical radio-frequency generators applicable to almost the full range of high-frequency heating work. These standard stock oscillators are being built in a wide range of sizes: 2, 5, 10, 20, 50, 100, and 200 kw.



A rock bit is being hardened in an experimental induction furnace (below). The bit, left, is still red hot.

A vast amount of laboratory experimentation yet remains to be done in both induction and dielectric heating, because as yet almost every product presents its own problems in frequency, power, and coil or plate design. Several examples of work done in the Westinghouse high-frequency laboratory of the past year indicate the variety of uses of this new branch of the industry.

The present methods of manufacturing the now popular hollow propeller blades for airplanes require that a copper or copper-alloy fillet be put in the leading and trailing edges to alleviate the effect of sharp corners. However, external welding is not sufficient to hold the two edges together; it would be desirable to have a weld along the edge on the *inside.* Obviously, this is an impossible spot for welding—but not for induction heating, or perhaps, it should be called induction brazing. Beads of the brazing material are laid along the inner edge. The propeller-to-be is then moved edgewise through the output coil of an oscillator and the beads are fused, securely binding the edges together. This brazing has been done with a torch but this takes much longer, requires a more skilled operator, and results in more warpage of the blades than the induction method.

Oil-well drill bits must be tough, for they must bore their way through solid rock. The tougher they are the longer they can stay down on the job without having to be laboriously hauled perhaps thousands of feet to the surface to be replaced by a sharpened set. Drill bits get their toughness from a layer of tungsten carbide deposited on the teeth under high heat. This has been done with a torch, the operator laboriously and slowly carbiding each of the 20 teeth of a bit one at a time. Experiments in the Westinghouse high-frequency experimental laboratory indicate the whole bit can be carbided by a patented process in a few seconds by passing the toothed cutter into the field of a high-frequency oscillator, the carbide particles being held in place by an adhesive coating until they

A fillet is brazed by high-frequency induction along the inside edge of a hollow propeller for an airplane. This method is much quicker and gives better results than a torch.

Nearly 10 000 kilowatts of high-frequency induction heating equipments have been installed to flow tin on tin plate.

merge with the steel base. The induction process insures uniformity of heating of all 20 teeth, cuts down the time, can be made a high-speed and semi-automatic without skilled operators. Protective atmosphere can be used.

A laboratory demonstration proves the worth of induction heating for soldering. A terminal connector for a fighter plane had thirty wires to be soldered to it. This had been done by hand, one wire at a time, requiring about fifteen minutes for the job. All connections were soldered at once by induction heating in fifteen seconds, all joints being clean and uniform.

A large chemical company learned of the flowing of tin on tin plate by induction to obtain a bright surface. If induction could do this with tin, perhaps it could do it for a new kind of plastic made in large sheets in which the two surfaces were required to be made absolutely smooth. This had been done by heating the surface between two steam-heated platens. This experiment with high-frequency heating indicates that by using thinner platens and about 200 kilocycles, the heating can be done more quickly because of elimination of delays required for heating and cooling of the steam platens.

Much work has been done on applying high frequencies to objects that are insulators instead of conductors, i. e., dielectric heating. Representative of these are the curing of plastics and the drying of the synthetic binders in making large sheets of multi-ply plywood. A great deal of work has been done on the problem of obtaining uniform voltage stresses over the large areas involved.

New Carrier Current Does Ten Jobs at Once

CARRIER current is the means used for making transmission-line conductors carry not only electric power, but also intelligence such as voice, relaying, telemetering, or control signals. The scheme generally employed has been to generate a carrier or radio-frequency signal and superimpose it on the transmission lines. By keying (starting and stopping) this carrier wave on a code basis, various relaying, supervisory, or metering signals can be transmitted one at a time. Or the wave can be modulated by audio waves for voice communication. But obviously, when the carrier wave is interrupted to carry one kind of signals, it cannot be used to perform other chores.

New equipment now makes this possible. A carrier frequency is generated as before, but it is transmitted continuously. It serves as a continuous vehicle for as many as ten independent tones or audio waves, each of which can be used as a channel for a different function. Thus, it is possible to have ten different pieces of intelligence sent simultaneously with other functions, six of the tones must be dropped out to accommodate a frequency band wide enough for satisfactory communication. This still leaves four tones for other func-

tions that continue without interfering with or interference by the conversation.

In addition to this great increase in application flexibility, the new carrier equipment (called the JY) is also arranged for maximum mechanical flexibility. The transmitter and receiver panels, the individual tone panels, and all other auxiliary panels, are standard 19-inch relay rack type, which permits convenient arrangement in many desired combinations. Several sizes of cabinets are available, all of which are equipped with hinged frame on which the various units are mounted. This construction provides the utmost of accessibility and permits addition of components when future expansion demands it.

New type carrier current provides ten continuous channels for the transmission of relaying, voice, or other signals.

Precision Probing—by X-Ray

ENGINEERS are good at finding things (except possibly at home). They have made it possible to bomb with precision a small target from 30 000 feet, to locate enemy airplanes while they are still below the curved horizon of the earth, to detect a deeply submerged submarine, to find an ore body or oil pool deep in the earth. Also, locating—with great precision—an object only a few inches away has become a vital war problem, vital because the lives of American boys are at stake.

An aviator is hit by flak; a soldier has been shot. If the field-hospital surgeon has exact knowledge of the position of the buried metal, its shape and angle, its relation to vital organs and bones, the injured fighter has a chance of more rapid or more complete recovery. With this exact knowledge, the surgeon does not have to probe for the hidden metal; he can go directly to it from the most appropriate spot, with the least disturbance to overlying vital organs. Also, he can reach the metal in the shortest time which does so much to alleviate the operational shock to the injured man.

To provide Army surgeons with this invaluable information, Westinghouse x-ray engineers have developed a locating device that serves as an adjunct to the Army's field x-ray equipment. The wounded man is brought into the x-ray room or tent on a stretcher. Without moving him from the stretcher, a careful exploration with the fluoroscope is made from head to toe for buried steel. If necessary, x-ray pictures are taken on film. When a bit of metal is found a locating device, called a Biplane Marker, is brought into action. It is a system of graduated scales, sighting cross-hairs, and an iodine marker, and is used with the x-ray tube and fluoroscope screen on the x-ray field-unit. Simply by taking a "sight" with the fluoroscope on the object, its position is established with respect to two reference iodine marks on the skin in two planes (surveyors would call them bench marks), the patient is made ready for the operating table.

But what good are the vertical and horizontal skin spots if the patient is not placed on the operating table in exactly the position he assumed on the stretcher? The reorientating device meets this problem in a moment. It is a right-angle caliper with two pointers and a spirit level at the right angle. One pointer is placed on the top skin spot and the second on the other spot, and the patient is gently adjusted until the bubble in the level is at dead center. His original position is then the same as on the stretcher.

This reorientation caliper, mounted on a stand and fitted with a calibrated probe, can be used by the surgeon to establish depth of the foreign body in the tissue; he can judge the distance he has yet to cut, or determine if the angle of his incision is correct.

By means of an auxiliary probe employed with the reorientating calipers, it is also possible to tell the surgeon the depth of the foreign body and the correct angle of incision from any third point of entry he may select.

The complete field unit with marking device can be disassembled by a skilled crew and packed in its fitted trunks in two and a half minutes. The entire unit weighs less than 700 pounds, the heaviest section of which weighs approximately 125 pounds and measures 19 inches by 34 inches by 45 inches when packed. This speed of disassembly and comparatively light weight of the component parts make it possible to move the apparatus with the speed necessary in modern warfare.

Production-Line X-Rays on Miniature Film

X-RAY machines have joined the production lines. Industry long ago found x-rays invaluable for product inspection, but the cost of apparatus and film restricted its use to special or critically important work. These objections have been disposed of by a radiograph that can fit into the production line and that can provide photographic records for a nickel instead of a dollar and a half.

This equipment uses a high-speed camera to take on 2-inch film (instead of larger sizes, up to 14 by 17 inches) any image cast upon a foot-square fluorescent screen by x-radiation. In other words, the machine photographs and proportionately reduces on miniature film the x-ray image shown on a large fluoroscope screen. About 300 exposures can be made on a single 50-foot continuous roll of film without stopping to reload as heretofore.

To accommodate the radiograph to factory production lines it has been engineered so as not to require the usual lead-lined surroundings for safety to workers. It is made in two sections, the water-cooled x-ray tube being contained in the upper head, which engages with the lower section.

A complete x-ray examination laboratory in a three-ton truck can be quickly drawn up at a dock to meet an incoming ship or can be driven to a naval training center for photofluorographic examination of the men. In this truck are all the necessary facilities for exposing and processing 35-mm films. It has a complete photographic darkroom, automatic refrigerated temperature-controlled film-processing tank, a heater to warm the truck in cold weather, a synchronous converter, and other auxiliary equipment. As many as 600 patients have been x-rayed in a single day.

and in which is located the casting and the fluoroscope screen. Hence not even so much as the operator's hand can be unwittingly exposed to the penetrating rays.

This industrial radiographic equipment, although not applicable to all types of product inspection, is of particular importance now that strenuous efforts are being made by designers to strip each piece of all material that does not contribute to strength or functional betterment. This makes it all the more necessary that flaws in the product be detected early in the manufacturing process.

A Commando-Tough Radio

There can be nothing delicate about military radios. One set of radio transmitters and receivers must be able to withstand a ducking during a beaching operation and be ready for immediate service following. The sets are sealed in watertight cases of which the one at the right has just received a test dunking.

WITH communication absolutely essential, Allied troops storming an enemy shore must have radio transmitters and receivers. In those critical moments of beaching under fire, radio equipment cannot be given the careful treatment its inherent fragility commands. Instead, the radio sets go overboard into the surf along with the men, and are dragged ashore to be set up and ready to pass vital information in a matter of minutes. Also, they must be insensitive to wide temperature ranges, be it the sub-zero of the Arctic or the boiling sun of the tropics. In achieving all this toughness, material cannot be used wantonly, for the receivers and transmitters are sometimes flown into the front-line positions; hence light weight is of super-importance.

The equipment was designed to have the greatest possible flexibility in performance without undue complication of operation. The receiving set has two degrees of selectivity, automatic volume control, a beat-frequency oscillator for continuous-wave reception and an output limiter, as well as a noise limiter. All frequency-determining components have been temperature compensated.

Tissue-Thin Transformer Steel

TINY, tightly wound coils of paper-thin steel have a mighty big place in this war. In fact, without the development that led to super-thin transformer steels some of the radio-detecting devices of great military importance would not be possible, because insufficient power would be available.

It is a research-idea-makes-good story. Just a few months before the attack on Pearl Harbor, research and transformer engineers announced a new kind of cold-rolled silicon-steel, trademarked Hipersil, in which the grains are oriented or alined in one predominant direction. This grain orientation results in a much higher permeability at high transformer inductions. Also, with this steel it is possible to make transformer cores by an entirely new and much faster method than stacking punched laminations by hand in the usual manner. Ribbons of it are wound into the proper core shape, like a flattened roll of adding-machine tape. This steel and core construction has been used with great success in power and distribution transformers to increase greatly the output obtainable from a given amount of material.

Then came the war, and with it the need for radio and communication sets—tens of thousands of them. Scores of new types were created by the radio engineer, some for operation on 400- and 800-cycle power supplies, many to operate at or deliver frequencies far higher than had been dreamed of a few years ago. Transformer losses and heating increase enormously as frequency is increased.

To keep these within acceptable bounds the transformer-core laminations must become thinner. Conventional Hipersil cores before the war were 29 gauge—about fourteen mils (0.014 inch) thick. To meet the new demand, rolling-mill, transformer, and metallurgical engineers succeeded in producing seven-mil-Hipersil cores, which permitted a reduction of one-third to one-half in the space and weight of choke coils, reactors, and transformers for radio sets that must be carried in planes or on men's backs. However, that achievement was still not enough. To obtain satisfactory outputs at higher frequency apparatus the laminations had to be still thinner—much thinner. After much research and development the engineers have been able to produce, first, steel three mils thick, and, more recently, two mils thick. An entirely new rolling-mill technique and new annealing practices were required. This ultra-thin transformer steel—half as thick as the paper on which these words are printed—has made possible highly efficient apparatus using cores weighing as little as one-fifth of an ounce up to seven pounds. The technique of winding these cores from a continuous ribbon of steel, instead of having to be built up of thousands of flimsy L- or E-shaped punchings, has not only made the applications possible but also has resulted in the savings of thousands of war-production man-hours.

Cores for transformers for very high frequencies become very small. Efficient ones are possible with the new ultra-thin Hipersil.

Midget-Size Transformers

IMAGINE a 35-kva, three-phase transformer small enough and light enough to tuck under your arm. This peewee transformer is only five inches high and weighs but 25 pounds. The ordinary single-phase, 37 ½-kva transformer weighs 680 pounds; even the one with a Hipersil steel core weighs 430 pounds. The most important factor leading to this diminutiveness is the frequency, 400 cycles. This 250/30-volt transformer is a part of that whole new family of electrical equipments brought into being for 400-cycle a-c systems for aircraft. This transformer uses class-B insulation, is air cooled, and could weigh even less, except for the fact that a compromise is desirable between losses and weight.

Another group of 400-cycle transformers displays even more startling weight savings. A 7½-kva, three-phase, 208-190/21-26.5-volt transformer weighs but nine and a third pounds. It is intended for an aircraft application by the Federal Telephone and Radio Co. It is forced air-cooled, and has, as an unusual feature, a regulating winding by which the secondary voltage is maintained constant over a 30 per cent range. Thus, by added control equipment, constant d-c voltage can be maintained, compensating for voltage drop in the rectifier, transformer, and supply circuit. The cores are made of the new thin-gauge Hipersil steel, which gives low losses, and results in much less total transformer weight at this higher frequency.

ENGINEERING PROFILES

The arrival of the gas turbine will probably be earlier because of war-forced development of high-temperature alloys. The gas turbine has been just around the corner for many years, but laboratory developments, as yet incomplete, indicate that practical gas turbines will be available after the war. Probably we shall see them first on locomotives where some economy can be sacrificed for convenience. The first of the powerhouse gas turbines will probably be small, high-speed geared units (say 3000 kw at 15 000 rpm) of the open-cycle type located near load centers close to the point of utilization of the electrical energy. Such prime movers would also be convenient for installation in small generating plants. For larger blocks of power such as required in the main power stations, a battery of small units might be used with the individual units started and stopped in more or less push-button fashion to operate at peak efficiency. Another later development step may be in the direction of large-capacity individual gas-turbine units of the closed-cycle type complete with heat exchangers, etc., and having efficiencies approaching those of modern steam units.

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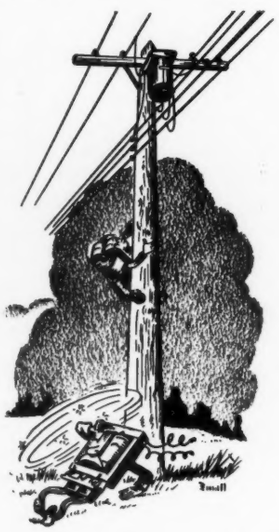
Most people consider themselves lucky to get repairs made at all, much less achieve any improvement in the process. Power companies, however, have found themselves in this happy situation with respect to distribution transformers. Because only a few distribution transformers are being manufactured now the old ones must be kept in repair. Many of the older



units in which coils have failed have been fitted with new Hipersil cores and new windings. Because Hipersil cores are so much smaller than the old cores of hot-rolled silicon, it is usually possible to get a core of the next larger size in the old tank. Thus, for example, an old five-kva distribution transformer becomes, with a Hipersil core, good for seven and one-half kva; a seven and one-half kva unit is given a capacity of ten kva, etc. This is accomplished without requiring more core, copper, or insulation and of course with the saving of the old tank, bushings, and other parts.

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Locomotive builders foresee a need for a high-speed locomotive of greater horsepower than is obtainable from reciprocating engines of allowable weight and length. Their answer may lie in using a geared-turbine power plant, as has been done so successfully for many years in ships. An

experimental unit is under construction. Calculations for this locomotive drive, which will deliver about 6500 hp, indicate a reduction of over a fourth in the steam required as compared to the conventional reciprocating steam locomotive.

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The same servo-mechanism principles that enable American tanks to fire on the run with such devastating effect quite possibly will be applied to giving us "floating" rides in high-speed trains and other vehicles. Actual development work on these applications has been started. Calculations show that the power required to stabilize the vertical movement of a railroad coach is only about three horsepower. Physically the apparatus is small enough to fit into an overnight bag. Curiously enough the servo-mechanism to stabilize a railroad car will require no more power and be no larger than that needed for an automobile. This is because the equipment required depends on the weight of the object multiplied by the square of the vertical movement of the road. The automobile is much lighter, but the vertical movement is several times that encountered by a railroad coach.

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Last spring Westinghouse research chemists were formulating new plastics, hoping to achieve an electrical insulation with certain properties. One of the resulting plastics, while not close enough to material sought as insulation, did prove to be the answer to another unrelated problem. A material was needed for models in making three-dimensional photoelastic studies of stresses in structural members. Plastic suitable for these models has been obtainable only in small pieces—sheets of less than 100 square inches and ¾ inch thick. Even these pieces have required several months to a year to cure.

This new plastic has no such limits. It can be made in large hunks. Already it has been made in a laboratory way in pieces 600 square inches by three inches thick, and can be cured in two days.

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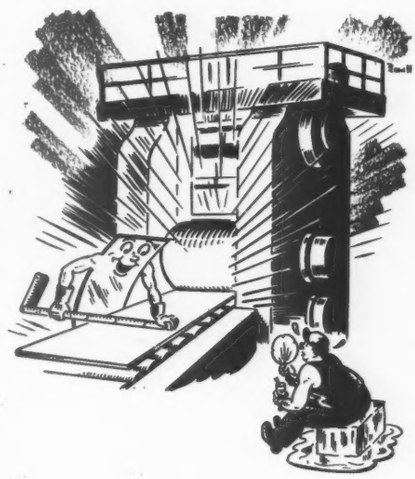
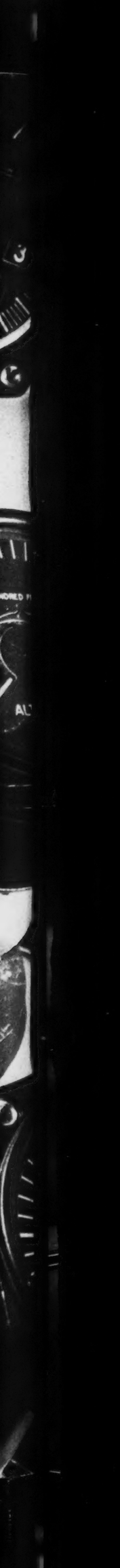
A few mirrors and a knowledge of optics were put together to solve a steel-mill problem. A white-hot slab of steel is swiftly squeezed out between the rolls of a rolling mill. For economy of steel and for maximum production, the operator needs to know accurately and quickly how wide the slab is. It is much too hot to get near. Mechanical gauges have their failings. With a method developed by a Westinghouse research engineer, an image of the slab is picked up in a convex



mirror and reflected to another mirror on which is a set of graduations equivalent to one-half inch at the slab. By adjusting the image of the steel on the scale in the mirror the mill operator can determine the steel width from a comfortable distance.

HUNDRED FEET
ON
ALTITUDE
RANGE
Aircraft pilots live by their instruments. The war has called into being dozens of wholly new types of instruments and has demanded increased production of aircraft instruments by several thousand per cent.